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TECHNICAL EVALUATION OF THE PROTOTYPE ORNL ALPHA RADIATION DETECTOR/PROBE WITH THE AN/PDR-77 RADIAC SET

MICHAEL J. BASSO
IRA A. KAPLOWITZ

ELECTRONIC WARFARE/RECONNAISSANCE SURVEILLANCE AND TARGET ACQUISITION DIRECTORATE
SENSOR SYSTEMS DIVISION

June 1992

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Michael J. Basso
Ira A. Kaplowitz

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13. ABSTRACT *(Maximum 200 words)*
A new Alpha particle detector, designed and fabricated by the Oak Ridge National Laboratory (ORNL) was procured and technically evaluated by the U.S. Army. Two of the three detectors procured were tested under guidelines obtained from U.S. Army requirements for an Alpha detector probe. The probes represent the state-of-the-art in Alpha particle detector design and fabrication affording ruggedness in design, accuracy at low count rates (±10%) below 30 CPM, excellent operating temperature (-30 to 60 deg C), and insensitivity to gamma rays (CS-137) up to 2 R/hr. Its unique feature centers on the solid state construction of the Alpha detector which is composed of a transparent epoxy having embedded silver actuated zinc sulfide as the scintillator. A flat light pipe coupled to a photomultiplier tube provides the light sensing design. Test results indicate a drop in response as one approaches the edge of the detector face due to the geometry of a flat light pipe design, suggesting a redesign from a flat geometry to one having a cone shape.

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FOREWORD

The Electronic Warfare, Reconnaissance, Surveillance and Target Acquisition Directorate (EW/RSTAD), in consonance with their official mission of developing new radiac equipment for the US Army, procured and received for test and evaluation three (3) prototype Alpha Probes from Oak Ridge National Laboratory (ORNL), for use with the AN/PDR-77 Radiac Set. These probes represent the state of the art in alpha particle detector design and fabrication. If acceptable to the US Army, this technology may yield great benefits in the maintenance and use of Alpha Radiacs. The prototype probes use a solid state detector, in contrast to the thin layer of aluminized mylar, coated with a scintillator made of silver activated zinc sulfide, now in use in the Army's Alpha Radiacs. The solid state detector is composed of a transparent epoxy which contains a scintillator, located near the surface of the epoxy, composed of silver activated zinc sulfide. A description of the design and fabrication technique of the detector are presented in Appendix C. The following test procedure and data are the result of an in house effort to technically assess the performance characteristics of this new device in relation to the US Army's requirements. Major detector characteristics are shown in figures 14 and 14A for the two probes tested.

PREPARED BY: Michael J Basso

MICHAEL J. BASSO
PHYSICIST
RADIAC SYSTEMS BRANCH
SENSOR SYSTEMS DIVISION

Ira A. Kaplowitz

IRA A. KAPLOWITZ
ELECTRONIC ENGINEER
RADIAC SYSTEMS BRANCH
SENSOR SYSTEMS DIVISION

REVIEWED BY:

ROBERT W. LEDERMAN
CHIEF, RADIAC SYSTEMS BRANCH
SENSOR SYSTEMS DIVISION

APPROVED BY:

EDWARD O. GROEBER, JR.
ACTING DEPUTY DIRECTOR
EW/RSTA DIRECTORATE

PREFACE

This document is the result of a testing effort to assess the technical performance of a new Alpha radiation detector design. The guidelines for this test effort were established by the US Army requirements for an Alpha Probe. The testing was conducted as an internal EW/RSTA Directorate effort utilizing in house personnel and facilities. The test data set forth in this document are based on a small sample of Alpha Probes. Therefore, the conclusions can not be based solely on statistics, but also on scientific judgement and experience.

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1. PRETEST

(a) Definitions

(1) EFFICIENCY: The efficiency of the Alpha Detector is defined as the ability of the detector to detect the calibrated count rate (in counts per minute, or CPM) of alpha particles emitted from a calibrated source in 2Pi geometry with no additional electronic amplification by the AN/PDR-77. The internal AN/PDR-77 amplification adjustment switches H and J are set to zero when efficiency is determined.

(2) ACCURACY: The accuracy of the Alpha Detector is the ability of the detector to count the calibrated number of alpha particles emitted per minute from an alpha source in 2Pi geometry, after having been calibrated using the AN/PDR-77 internal electronic amplification switches H and J.

(3) ALPHA DETECTOR FACE AREA: The Alpha Probe has an Alpha Detector that is solid state in construction and is protected by am aluminum grid which divides the area of the probe face into nine (9) segments (See figure 5A). When calibrating the Alpha Probe using the AN/PDR-77 Calibration Fixture and the AN/UDM-6 Radiac Calibrator, only segment #2 of the probe face is calibrated. (See figures 3 and 6.)

(4) CPM versus DPM: The term CPM (Counts per Minute) refers to the number of alpha particles emitted per minute in a 2Pi geometry. The term DPM (Disintegrations per minute) refers to the number of nuclei in the source which disintegrate each minute in a 4Pi geometry. In the case of the AN/UDM-6, Plutonium 239 is electroplated as a thin coat on a metal disc and the thickness of the layer is so small that it does not present a problem in self absorption of the alpha particles.

(5) INTEGRATED ALPHA DETECTOR FACE AREA ACCURACY: This accuracy is the sum total of each of the accuracies of the individual segments of the face area, divided by nine to achieve the average accuracy per segment.

(6) ALPHA PROBE DESIGNATED IDENTITIES: The two (2) Alpha Probes tested were assigned the identities of Probe A-1 and Probe A-2. Their respective serial numbers are AP094001 and AP094003.

(7) CALIBRATED ATTENUATORS DESIGNATED IDENTITIES: The three calibrated attenuators were given the following identities: The attenuator having an attenuation factor of .981 was designated K-1, that having an attenuation factor of .662 was designated K-2, and that having an attenuation factor of .961 was designated K-3.

(8) ENERGY DETECTION THRESHOLD: The energy of the least energetic alpha particle which the radiac can successfully detect (count). The alpha particle must possess enough kinetic energy to penetrate the aluminum (light tight) layer as well as the epoxy material of the detector itself, and still produce sufficient photons by colliding with the Zinc Sulfide scintillator. These photons are collected by the light pipe and detected by the photomultiplier tube, whose output is an electronic pulse. The amplitude of this pulse is greater than the electronic discriminator threshold, allowing the event to be counted by the radiacmeter.

(9) AN/UDM-6 RADIAC CALIBRATOR: A set of four calibrated Pu^{239} sources which provide (nominal) count rates of 1,000, 10,000, 100,000, and 1,000,000 CPM. A letter of certification from the US Army Primary Nucleonics Laboratory at Sacramento, California, is included in Appendix C. This letter also gives the exact, calibrated count rates.

(b) <u>POST-TEST RESULTS</u>

The following observations and conclusions are based on the data accumulated during testing. Measured test values are summarized and presented in Table 1.

(a) <u>Calibration:</u> The alpha probe was easily calibrated following the calibration procedure outlined in the Test Plan. This calibration was maintained throughout the testing program.

(b) <u>Range:</u> The measured range of the Alpha Probe extended from 21 CPM to 1358 KCPM in the total count mode while maintaining the required accuracy of ±10%. In the count rate mode, the Alpha Probe demonstrates compliance for count rates in the order of magnitude of 10^3, 10^4, and 10^5 CPM. At count rates of the order of 10^6 CPM, which exceeds the range of the instrument, the display read 999 KCPM.

(c) <u>Linearity:</u>

(1) Low Range: The measured linearity at the lower end of the range demonstrated compliance (±10% accuracy) with the requirements. The low range linearity test included the following count rate levels: 26, 465, and 1376 CPM.

(2) High Range: The measured linearity at the high CPM range also demonstrated compliance (±10% accuracy) with the requirements. The high range linearity test consisted of the following CPM levels: 11799, 121560, and 1,113,522 CPM.

(d) Energy Threshold: The minimum energy level for Alpha Particle detection for both prototypes tested meets the requirement for an energy threshold of 3 MeV or less.

(e) Gamma Response: Both prototypes demonstrated zero counts when exposed to a gamma field of 1 R/hr. This result meets the Army requirement of demonstrating a count rate of 25,000 CPM or less in a 1 R/hr gamma field. At higher gamma intensities, the Alpha Probe demonstrated a susceptibility by exhibiting a drop off in the measured alpha count rate. (See figure 10.) The observed drop in the alpha count rate is not considered a discrepancy, since the effective gamma dose rate would be too harmful to the operator for practical use of an alpha radiac.

(f) Battery Life: Both prototypes exceeded the fifty hour operational requirement. However, the battery life depends on the current drain, which is determined by the mode in which the AN/PDR-77 is operated. Alpha probe A-1 was operated in the count rate mode, utilizing calibration source A (1376 CPM). During this test, the light in the radiacmeter was turned on for four hours, but no other indication (alarm or chirper) was used. The unit performed within the specified accuracy (±10%) for 93 hours, until the built in low battery indicator alarmed. The low battery indicator is designed to alarm when approximately ten hours of battery life remain. Alpha Probe A-2 was also operated in the count rate mode, utilizing source C (121,560 CPM). During this test the radiacmeter light was turned on for five hours, with no other indicator used. The unit performed within the specified accuracy (±10%) for 82 hours, until the built in low battery indicator alarmed. Recalibration of both units demonstrated that no changes occurred in the circuitry or detectors due to the battery failure. The same calibration switch settings were observed following the recalibration as before the battery test.

(g) Response Time: Both prototypes met the requirement of measuring the count rate of the calibration source with an accuracy of ±10% two minutes after being turned on, after having been off for no less than sixty minutes.

(h) Stability: Both prototypes met the stability requirements based on data obtained during the battery test.

(i) Light Leak: Probe A-2 exhibited a light leak. The leak was traced to segment #5 of the detector face. Subsequent analysis indicated a thinning of the aluminum layer, which acts as a light shield, at this particular location. A repair was effected using aqua-dag, a colloidal carbon solution.

(j) High Temperature (140°F/60°C): Both prototypes met the ±10% accuracy requirement at high temperature. Probe A-1 exhibited a drop in count rate readings of 3.4%, and probe A-2 exhibited a drop in readings of 8.9%.

(k) Detector Area Response: The average accuracy for both prototypes was evaluated. Results showed that Probe A-1 displayed an average segment accuracy for count rate of +6.8%, while Probe A-2 displayed an average segment accuracy for count rate of -16.4%. Probe A-2 does not meet the ±10% accuracy requirement when used in a large surface area contamination field. Probe A-2 data was acquired using an opaque black cloth draped over the detector to eliminate the effect of any light leak. Therefore, the data reflects the effects of fabrication and materials in the performance of detecting and counting alpha particles with Probe A-2.

Further analysis of the detector area data acquired with a small area collimator shows that the sensitivity of the detector face varies radially with the distance from the geometric center of the detector face. The photomultiplier tube (PMT) is typically located at this point on the detector, and logically the counting accuracy should be the highest at this location. As one moves away from the center, the counting accuracy decreases, as one approaches the edge of the detector. It is thought that this, the geometry of the light pipe being relatively thin, causes the shape of the light pulse generated by an incident alpha particle to become distorted, stretching the pulse, and thereby decreasing its height. If the pulse height is decreased sufficiently, it will fall below the discriminator voltage threshold. Other contributors may include an uneven distribution of Zinc Sulfide scintillator, or an uneven thickness of aluminum. These, however, would most likely be randomly distributed across the detector face, and not contribute to the radial decrease in count rate.

(l) Low Voltage Effect: The performance of both prototypes was acceptable, maintaining a ±10% accuracy in count rate for a voltage drop of greater than three volts, from an original stating voltage of nine volts. The readout from the radiacmeter became unstable between 4.5 and 5.0 volts.

(m) System Current Drain: The current drain for both prototypes was measured for different operating conditions and combinations, incorporating high and low count rates, back lighting off and on, chirper off and on, and audio alarm off and on. Results show that a minimum current drain occurs when the instrument is measuring count rate with the back light, the chirper, and the audio alarm all off. In this mode, the current drain averages approximately 10 mA. Measuring count rate with the back light, the chirper, and the audio alarm all on, and a count rate on the order of 10^6 CPM produces an average current drain of approximately 30 mA. Each BA-3090 battery can supply 20 mA for 20-25 hours. Therefore, three such batteries, as used in the AN/PDR-77, did supply sufficient power to operate an instrument for at least fifty hours.

(n) Low Temperature (-25°F/-32°C): Both prototype probes were subjected to a temperature of -25°F(-32°C). The radiacmeter was not exposed to the low temperature. Both prototypes maintained the same count rate accuracy as at room temperature for more than two hours at low temperature prior to termination of the test.

(c) Conclusions

The AN/PDR-77 Solid State Alpha Probe demonstrated a considerable improvement in performance and physical construction over earlier alpha particle detectors. Specifically, the major improvement is the solid state construction of the detector element, which eliminates the old problem of puncturing the thin zinc sulfide coated, aluminized, mylar "window" during field surveys. The durability of the present thin aluminum light barrier on the outer surface of the solid state alpha detector is unknown. A proper assessment would require field testing which would subject the instrument to rough terrain. Another improvement is the increased insensitivity to background gamma radiation for a gamma dose rate of 1 R/hr. This will allow area monitoring to be done in a higher background environment than was heretofore possible. Other positive design features include stability of the device at high and low temperatures, as well as excellent range and linearity. The unobstructed detector face area is much larger than that of the probes currently in use. The prototypes have an area of 100 cm^2, divided into nine segments, whereas the older probes have a wire mesh dividing 100 cm^2 into 320 smaller segments. The decrease in count rate radially from the center of the detector face (note earlier) should be improved. This may be done by replacement of the geometrically flat light pipe now used with one shaped to provide less distortion. For example, a cone shape might be used. It is, however, concluded that the prototype Alpha Particle Detector, designed by the Oak Ridge National Laboratory (ORNL), presents a vast improvement in the current design of alpha particle detectors.

Table I
SUMMARY OF MEASURED TEST RESULTS

1. Calibration:

Probe	Switch #2, Setting of H and J	
A-1	4	5
A-2	4	5

2. Range:

	Calibrated Count Rate *	Accuracy (5 min count) Probe A-1	Probe A-2	Accuracy (Count Rate) Probe A-1	Probe A-2
a.	26.8/21.07 CPM	.978	.982	N/A	N/A
b.	1376/1106 CPM	.996	1.02	.996	1.036
c.	11799/13126 CPM	.996	.980	1.020	.995
d.	121560/144320 CPM	.989	.962	1.020	.965
e.	1113522/1358710 CPM	.944	.933	Off Scale	1.010

* Left value for Probe A-1, right value for Probe A-2.

3. Linearity:

	Calibrated Count Rate	(Five minute count mode) Probe A-1	Probe A-2	(Count rate mode) Probe A-1	Probe A-2
a.	26.8/54.1 CPM	0.950	0.99		
b.	465.1 CPM	1.01	0.98		
c.	1376 CPM	0.997	0.98		
d.	11799 CPM	1.00	1.02		
e.	121560 CPM	1.01	0.989	0.995	0.969
f.	376370 CPM			1.00	0.981
g.	1113522 CPM	0.929	0.936		

4. Energy Detection Threshold:

	Alpha Energy (MeV)
Probe A-1	1.8 (Detector Area Segment #5)
Probe A-2	2.1 (Detector Area Segment #5)

5. Gamma Response

	Counts per Minute
Probe A-1	0.0
Probe A-2	0.0

6. Battery Test

	Time until Low Battery	Voltage when accuracy >10%	Calibration Check
Probe A-1	93 Hrs (Light on 4 Hrs)	5.5-6.0 VDC	OK
Probe A-2	82 Hrs (Light on 5 Hrs)	5.5-6.0 VDC	OK

7. Response Time: Power Off one hour to power On

Probe A-1 Accuracy Before: 97.9% Accuracy After: 98.7%
Probe A-2 Accuracy Before: 92.6% Accuracy After: 97.9%

Table I

SUMMARY OF MEASURED TEST RESULTS (Continued)

8. Stability: Accuracy stayed within specified limits.

Probe A-1	Yes
Probe A-2	Yes

Battery Replacement Restores Reading to Specified Accuracy:

Probe A-1	Yes
Probe A-2	Yes

9. Light Leak: All detector face area segments individually tested.

Probe A-1	No Failures
Probe A-2	Failure in one segment (Repairs effected)

10. High Temperature (60°C):

	Percent Change Room Temperature/High Temperature
Probe A-1	-3.4%
Probe A-2	-8.9%

11. Detector Area Response:

	Average of all nine segments.
Probe A-1	1.068 (+6.8%)
Probe A-2	0.836 (-16.4%)

12. Low Voltage Effect:

Voltage	Probe A-1	Probe A-2
9.0	12.9 KCPM	12.4 KCPM
8.5	12.9 KCPM	12.4 KCPM
8.0	12.9 KCPM	12.3 KCPM
7.5	12.9 KCPM	12.2 KCPM
7.0	12.6 KCPM	12.2 KCPM
6.5	12.4 KCPM	12.2 KCPM
6.0	11.9 KCPM	11.5 KCPM
5.5	11.3 KCPM	11.0 KCPM
5.0	10.0 KCPM	5.0 KCPM
4.5	4.0 KCPM	Erratic
4.0	Erratic	Erratic

Table I
SUMMARY OF MEASURED TEST RESULTS (Continued)

13. System Current Drain:

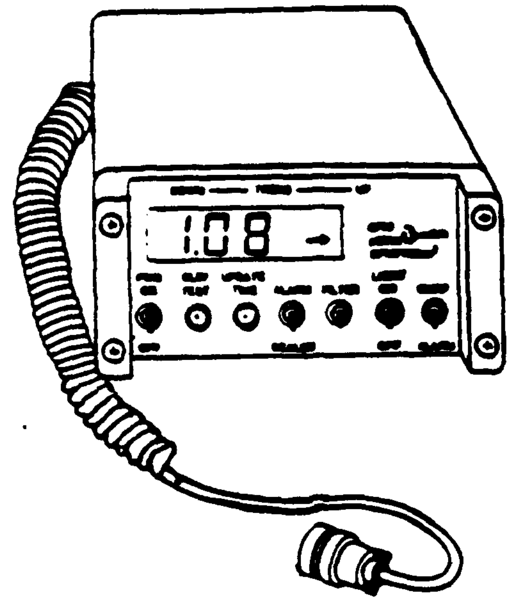
	Probe A-1	Probe A-2
Radiacmeter on, No Source, Light off	9.15 mA	11.50 mA
Radiacmeter on, No Source, Light on	18.25 mA	21.80 mA
Source A, No Light	10.10 mA	11.50 mA
Source A, Chirper On	11-13 mA	10.8-12.1 mA
Source A, Alarm On	17-26 mA	16-27 mA
Source C, No Light	10.10 mA	10.95-11.25 mA
Source C, Chirper On	16-25 mA	17-27 mA
Source C, Alarm On	17-26 mA	16-27 mA
Source D, No Light	10.10 mA	11.20 mA
Source D, Chirper On	18-28 mA	17-28 mA
Source D, Alarm On	17-27 mA	16-26 mA
Source D, Chirper On, Light on	25-37 mA	30-40 mA

14. Low Temperature (-32°C):

	Percent Change Room Temperature/Low Temperature
Probe A-1	+1.59%
Probe A-2	-0.85%

PORTABLE ALPHA-BETA-GAMMA SURVEY METER

AN/PDR-77( )



AN/PDR-77( )

ALPHA PROBE

LARGE AREA-100 CM^2

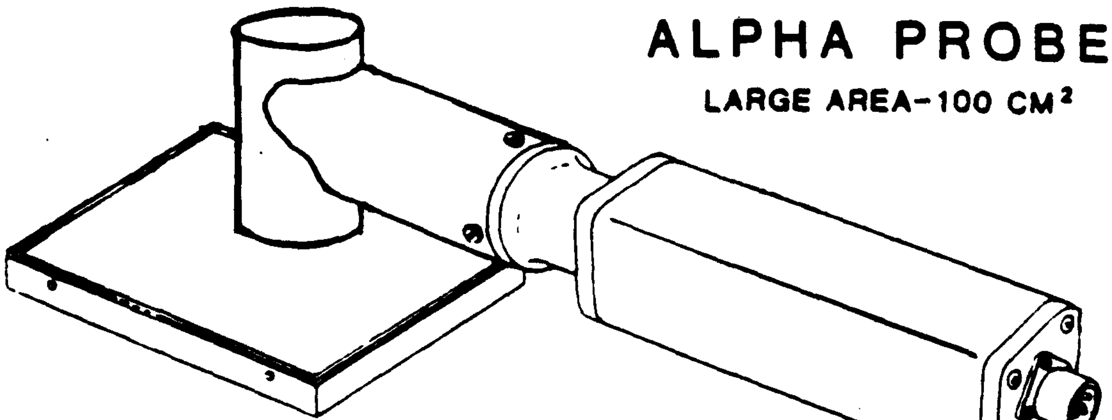


Figure 1

AN/PDR-77 with Prototype Alpha Probe

I. CALIBRATION TEST

A. Criteria:

The instrument shall be calibrated against Plutonium 239, using the AN/UDM-6 Alpha Radiac Calibrator. The meter indication shall be proportional to the concentration of radioactive material of the source.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. Screwdriver.
4. TM 11-6665-251-40.

C. Test Procedure:

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the calibrator, and each of the four calibrator sources, and the calibrator's calibration date in the indicated spaces on the data sheet. Record the calibrated count rate for each of the four calibrator sources in the indicated spaces on the data sheet.

2. Set the instrument for Scalar Mode, with a five minute counting time. Using the screwdriver, loosen the eight captive screws at the rear of the radiacmeter casing and slide the casing backward far enough to expose the slide switches.

3. Take a five minute Background Count, and record this number on the data sheet (Step 1).

4. Using the calibration fixture, take a five minute reading for Source A, and record this number on the data sheet (Step 2). (See Figures 2 to 6)

5. Using the calibration fixture, take a five minute reading for Source B, and record this number on the data sheet (Step 3).

6. Using the calibration fixture, take a five minute reading for Source C, and record this number on the data sheet (Step 4).

CALIBRATION TEST (Continued)

7. Divide the difference between the result of Step 2 and Step 1 (the Background Count on the data sheet) by five times the calibrated activity of source A, and record this number on Step 5 of the data sheet.

8. Divide the difference between the result of Step 3 and Step 1 (the Background Count on the data sheet) by five times the calibrated activity of source B, and record this number on Step 6 of the data sheet.

9. Divide the difference between the result of Step 4 and Step 1 (the Background Count on the data sheet) by five times the calibrated activity of source C, and record this number on Step 7 of the data sheet.

10. Add the results of Steps 5, 6, and 7 of the data sheet, then divide the total by three. Round this off to two decimal places, and record this number on Step 8 of the data sheet.

11. Use the result of step 10 above to set switches H and J on switch 2 IAW page B-11 of TM 11-6665-251-40 and record these settings on Step 9 of the data sheet.

12. Slide the casing back into position, and tighten the screws.

13. Repeat steps 3 through 9 above. If the results of steps 7, 8, or 9 for the second time are less than 0.90 or greater than 1.10, the instrument has failed the test.

DATA SHEET

Type Test: CALIBRATION. DATE: 19 Nov 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: AP094001 (A-1)

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P1559	1376		
B P1482	11799		
C P1907	121560		
D P2372	1113522		

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0

Test Data

1. Background Count: 9.59

2. Reading for Source A: 3.15K

3. Reading for Source B: 27.0 K

4. Reading for Source C: 270 K

5. Divide the difference between the result of Step 2 and the Background Count by five times the calibrated activity of source A: .457

6. Divide the difference between the result of Step 3 and the Background Count by five times the calibrated activity of source B: .458

7. Divide the difference between the result of Step 4 and the Background Count by five times the calibrated activity of source C: .444

8. Add the results of steps 5, 6, and 7, then divide by three. Round off to two decimal places: .453

9. Set switches H and J on switch 2. H: 4 J: 5

DATA SHEET

Type Test: CALIBRATION. DATE: 22 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P1559	1376		
B P1482	11799		
C P1907	121560		
D P2372	1113522		

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0

Test Data

1. Background Count: 3.21
2. Reading for Source A: 3.08 K
3. Reading for Source B: 27.1 K
4. Reading for Source C: 272 K
5. Divide the difference between the result of Step 2 and the Background Count by five times the calibrated activity of source A: .447
6. Divide the difference between the result of Step 3 and the Background Count by five times the calibrated activity of source B: .459
7. Divide the difference between the result of Step 4 and the Background Count by five times the calibrated activity of source C: .446
8. Add the results of steps 5, 6, and 7, then divide by three. Round off to two decimal places: .450
9. Set switches H and J on switch 2. H: 4 J: 5

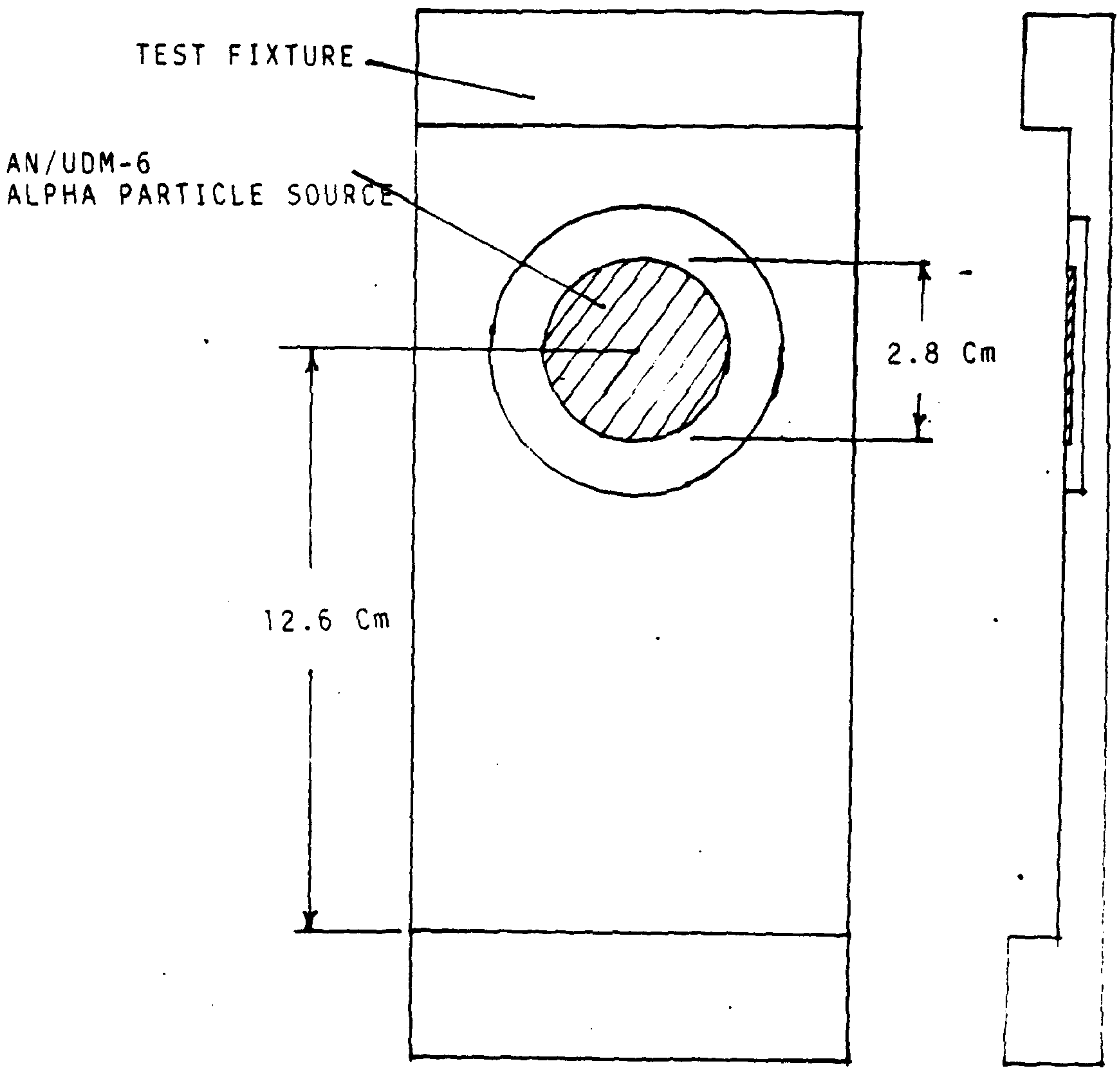


Figure 2

Test Fixture used with AN/UDM-6

Position of Prototype Alpha Probe in Test Fixture

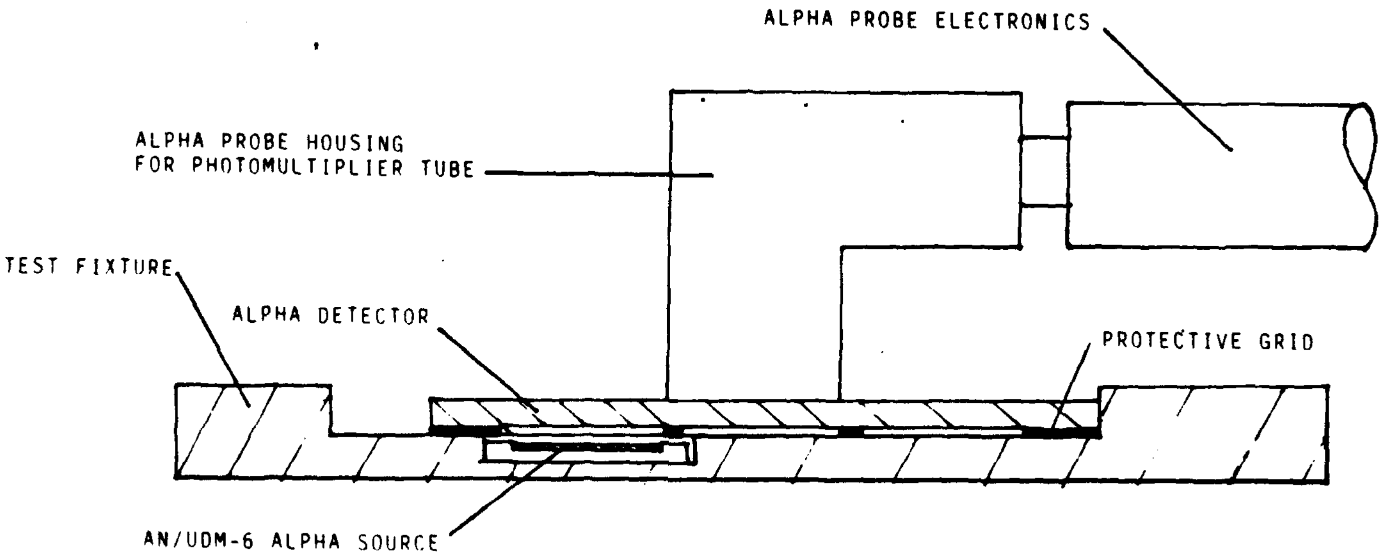


Figure 3

Prototype Alpha Probe and Test Fixture

Oak Ridge National Laboratory
Prototype Alpha Particle Detector

Scintillator #LL1990 - ZnS
6000 Å Aluminum + hardcoat
Hamamatsu R1924 PMT @ 900V, 200 mV input sensitivity
Light-tight to 10,000 ft. candles

Scintillator #101791 - ZnS
8000 Å Aluminum + hardcoat
Hamamatsu R1924 PMT @ 925V, 200 mV input sensitivity
Light-tight to 10,000 ft. candles

Figure 4

Alpha Probe Scintillator, Light Tight Coating Thickness, and Photomultiplier Tube

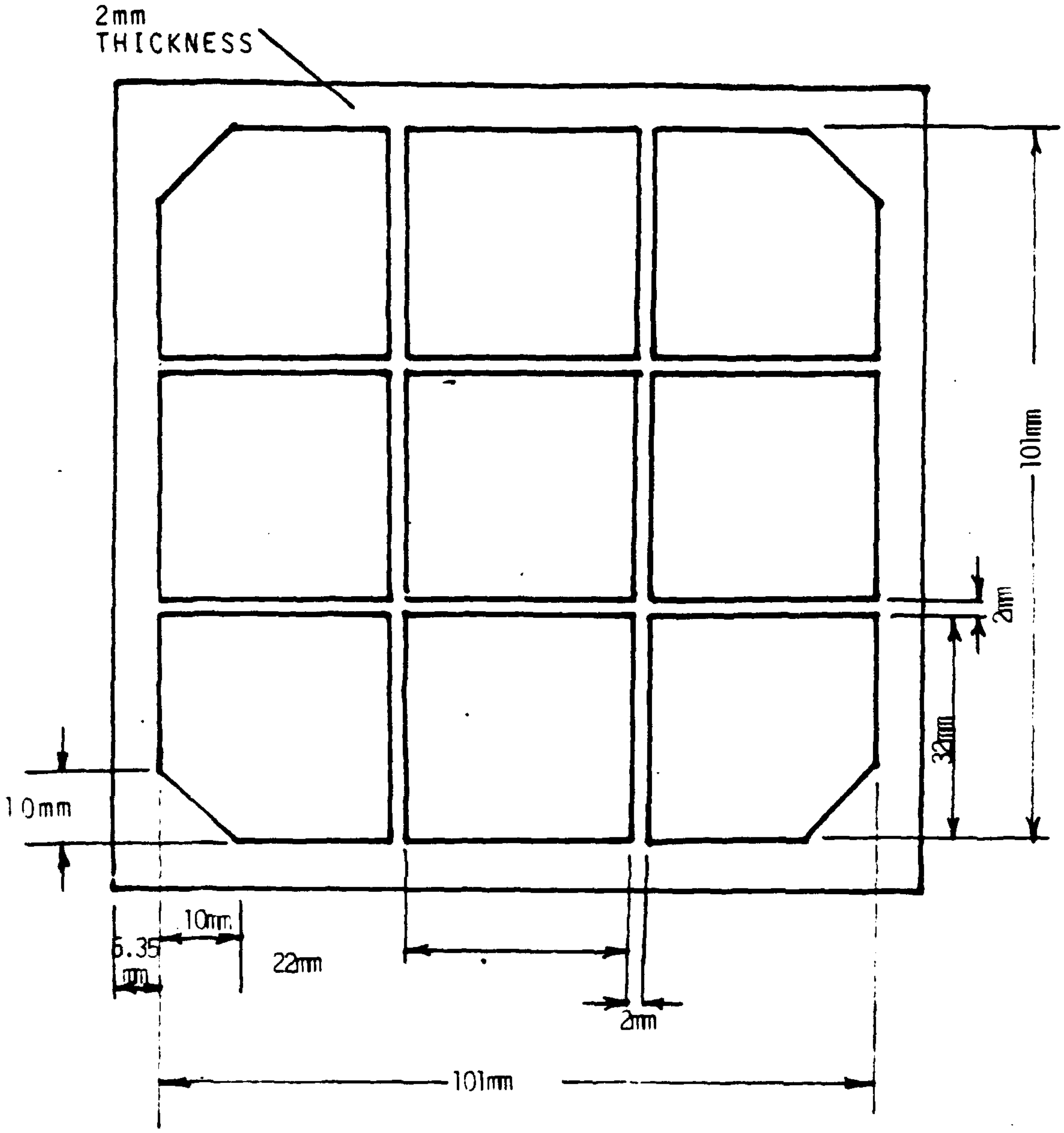


Figure 5

Alpha Probe Detector Face Dimensions

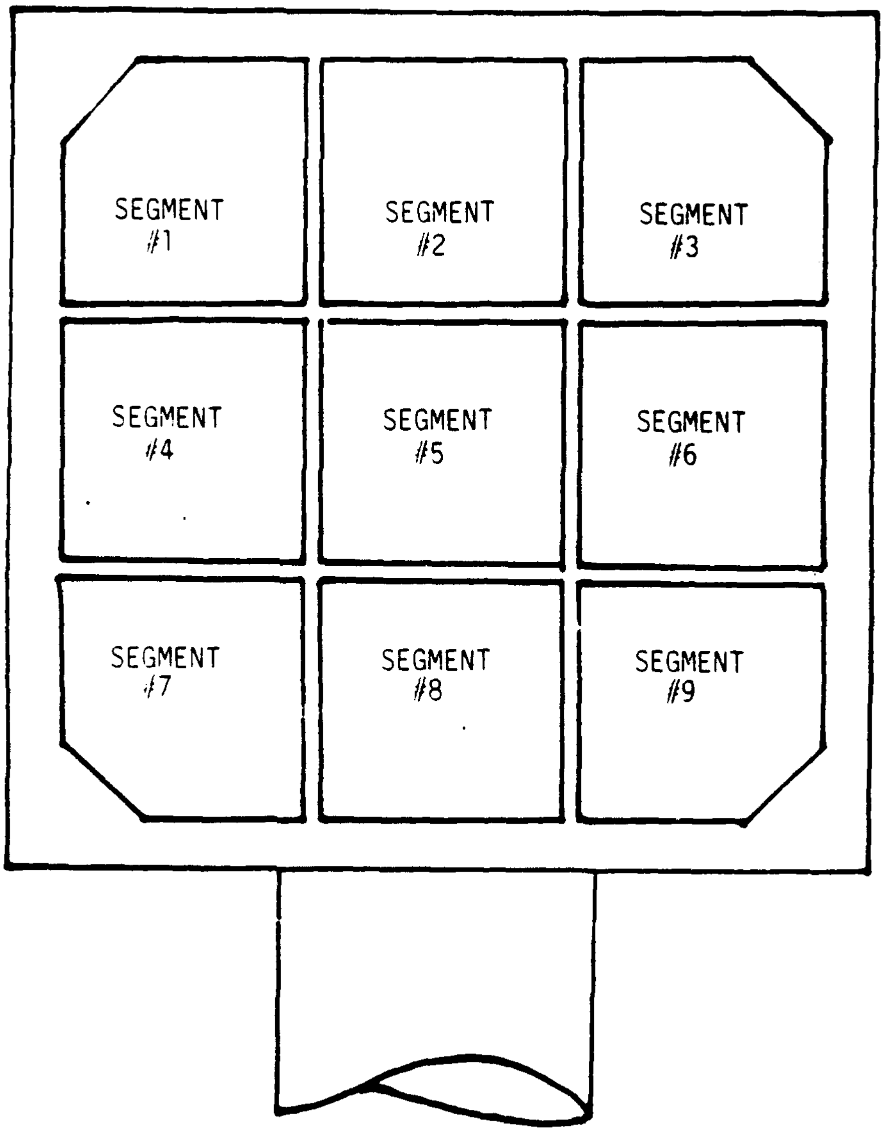


Figure 5a

Alpha Probe Detector Face Segments

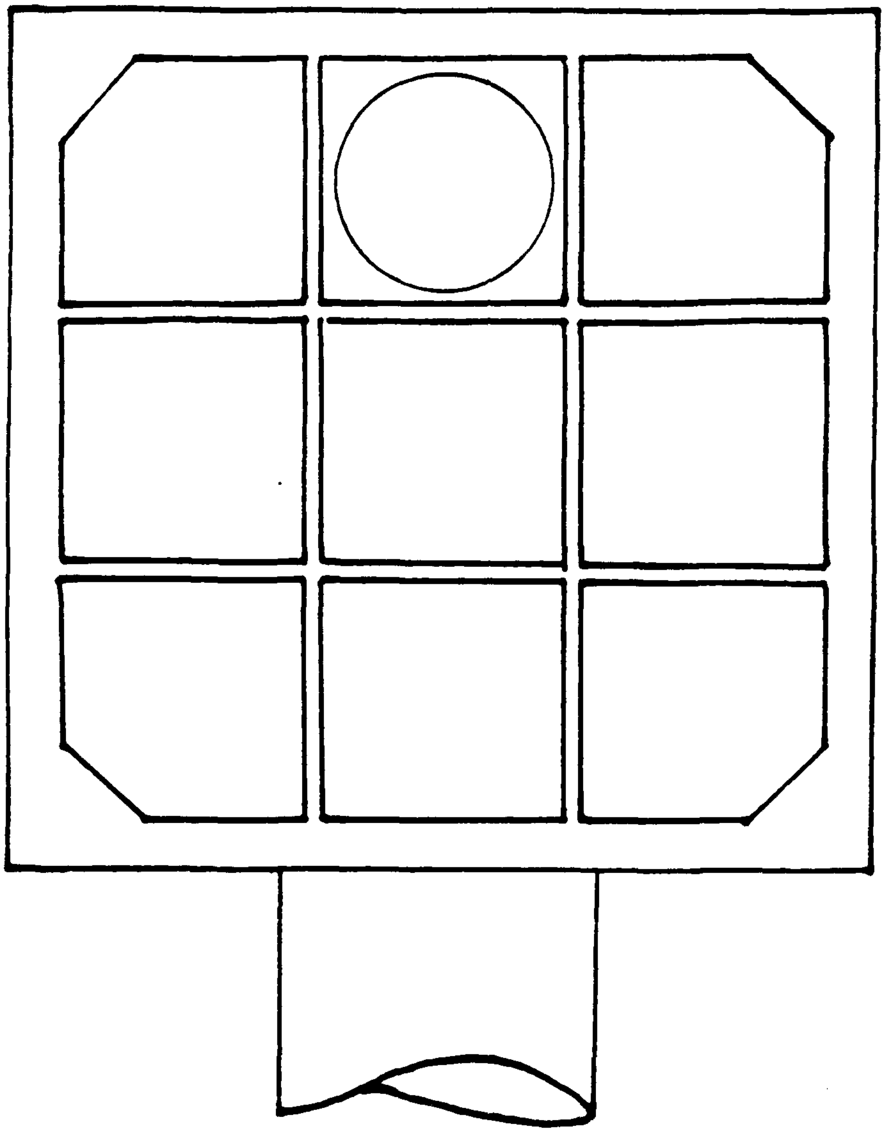


Figure 6

Calibration of Alpha Probe using Detector Segment #2

II. RANGE TEST

A. Criteria:

The instrument shall detect alpha particles, and shall indicate on a meter the rate in either counts per minute (CPM) or disintegrations per minute per 100 square centimeters (DPM/100cm^2) at which alpha particles are impinging upon the detector. The readout units should be user selectable. Desirable meter ranges are 0-10^6 CPM and 0-10^5 DPM/100cm^2.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. AN/UDM-6 Calibrated Attenuators (See figure 7).

C. Test Procedure:

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the calibrator, and each of the four calibrator sources, and the calibrator's calibration date in the indicated spaces on the data sheet. Record the calibrated count rate for each of the four calibrator sources in the indicated spaces on the data sheet. Take five 5 minute background counts and record them on the data sheet.

2. Set the instrument for Scalar Mode, with a five minute counting time. Take five 5 minute counts for sources A, B, and C, and record the results on the data sheet. (Steps 1, 2, and 3)

3. Then set the instrument for a 0.8 minute counting time, take five 0.8 minute counts using source D, and record the results on the data sheet. (Step 4)

4. Take the average of the readings for each of the four sources. For sources A, B, and C, divide the results by five. Take the average of the five readings for source D. Divide this result by 0.8, and record this on the data sheet. (Step 8) Divide Step 8 by the calibrated activity of source D and record on the data sheet. (Step 13)

II. RANGE TEST (Continued)

5. Set the counting time back to five minutes. Using source A with the K-1 attenuator, take five 5 minute counts, and record this on the data sheet. (Step 9). Average these readings, subtract the five minute background count taken during calibration, divide by five, and record the results on the data sheet. (Steps 9a and 9b)

6. Compare the results with the calibrated source count rates and record the results on the data sheet. (Steps 10 to 14)

7. Repeat steps 2 through 5 with the instrument in the count rate mode, and record the results on the data sheet. (Steps 15 to 19).

DATA SHEET

Type Test: RANGE.

DATE: 19 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: AP094001 (A-1)

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P1559	1376	K-1	26.8
B P1482	11799		
C P1907	121560		
D P2372	1113522		

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0 and 0.8

Test Data

Background Counts: 7.02

1. Readings for Source A: 6.67 K, 6.89K, 6.99K, 6.90 K, 6.80K
2. Readings for Source B: 58.7K, 59.2K, 58.5K, 59.1K, 58.1K
3. Readings for Source C: 605K, 602K, 597K, 608 K, 594K
4. Readings for Source D: 832 K, 849k, 844K, 847K, 835K
5. Average the readings for source A, and divide by five: 1.37 K CPM
6. Average the readings for source B, and divide by five: 11.74 K CPM
7. Average the readings for source C, and divide by five: 120.24 CPM
8. Average the readings for source D, and divide by 0.8: 1051.53 K CPM

DATA SHEET (Continued)

Type Test: RANGE (Continued). DATE: 20 NOV 91

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0

Probe S/N:________

9. Readings for Source A (with Attenuator K-1):

153 | 133 | 148 | 119 | 138 |

a. Average reading for source A with attenuator K-1: 138.13

b. Subtract background count from step 9.a and divide by 5: 26.22 CPM

10. Divide step 5 by calibrated activity of source A: .996

11. Divide step 6 by calibrated activity of source B: .995

12. Divide step 7 by calibrated activity of source C: .989

13. Divide step 8 by calibrated activity of source D: .944

14. Divide step 9.b by calibrated attenuated activity of source A:

.978

DATA SHEET (Continued)

Type Test: RANGE (Continued). DATE: 20 NOV 91

Probe S/N: A-1

15. Repeat procedure with instrument in count rate mode:

						Average
a. Readings for Source A:	1.36K	1.37K	1.38K	1.40K	1.36K	1.37K
b. Readings for Source B:	12.1K	12.3K	11.9K	12.0K	11.9K	12.04 K
c. Readings for Source C:	125 K	124 K	125K	123K	123K	124.0 K
d. Readings for Source D:	999+					OFF SCALE

16. Divide average count rate in step 15.a by source A calibrated activity: .998

17. Divide average count rate in step 15.b by source B calibrated activity: 1.020

18. Divide average count rate in step 15.c by source C calibrated activity: 1.020

19. Divide average count rate in step 15.d by source D calibrated activity: OFF SCALE

DATA SHEET

Type Test: RANGE. DATE: 23 MAR 92

Alpha Calibrator, AN/UDM-6 S/N: A1160

Calibration date: 24 JAN 92

Radiacmeter S/N: SM984103 Probe S/N: A-2

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P3150	1106	K-1	21.46
B P2724	13126		
C P2608	144320		
D P3159	1456589	K-2.	492327

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0 / .6

Test Data

Background Counts: 4.72, 7.08, 2.35, 2.35, 4.72

1. Readings for Source A: 5.79K, 5.76K, 5.42K, 5.50K, 5.69K
2. Readings for Source B: 63.8K, 64.8K, 65.0K, 64.0K, 63.9K
3. Readings for Source C: 698K, 696K, 693K, 693K, 691K
4. Readings for Source D: 814K, 812K, 819K, 806K, 817K
5. Average the readings for source A, and divide by five: 1.13K CPM
6. Average the readings for source B, and divide by five: 12.86 K CPM
7. Average the readings for source C, and divide by five: 138.84K CPM
8. Average the readings for source D, and divide by ~~0.3~~: 1358.71 K CPM
0.6

DATA SHEET (Continued)

Type Test: RANGE (Continued). DATE: 23 MAR 92

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0

Probe S/N: A-2

9. Readings for Source A (with Attenuator K-1):

117 | 102 | 114 | 98 | 117 |

a. Average reading for source A with attenuator K-1: 109.6

b. Subtract background count from step 9.a and divide by 5: 21.07 CPM

10. Divide step 5 by calibrated activity of source A: 1.020

11. Divide step 6 by calibrated activity of source B: .980

12. Divide step 7 by calibrated activity of source C: .962

13. Divide step 8 by calibrated activity of source D: .933

14. Divide step 9.b by calibrated attenuated activity of source A:

.982

DATA SHEET (Continued)

Type Test: RANGE (Continued). DATE: 23 MAR 92

15. Repeat procedure with instrument in count rate mode:

Probe S/N: A-2

						Average
a. Readings for Source A:	1.15K	1.12K	1.14K	1.15K	1.17K	1.146 K
b. Readings for Source B:	12.9K	13.1K	13.2K	13.1K	13.0K	13.06 K
c. Readings for Source C:	141 K	138K	139K	137K	140 K	139 K
d. Readings for Source D:	502K	494K	492K	501K	498K	497.4 K *

16. Divide average count rate in step 15.a by source A calibrated activity: 1.036

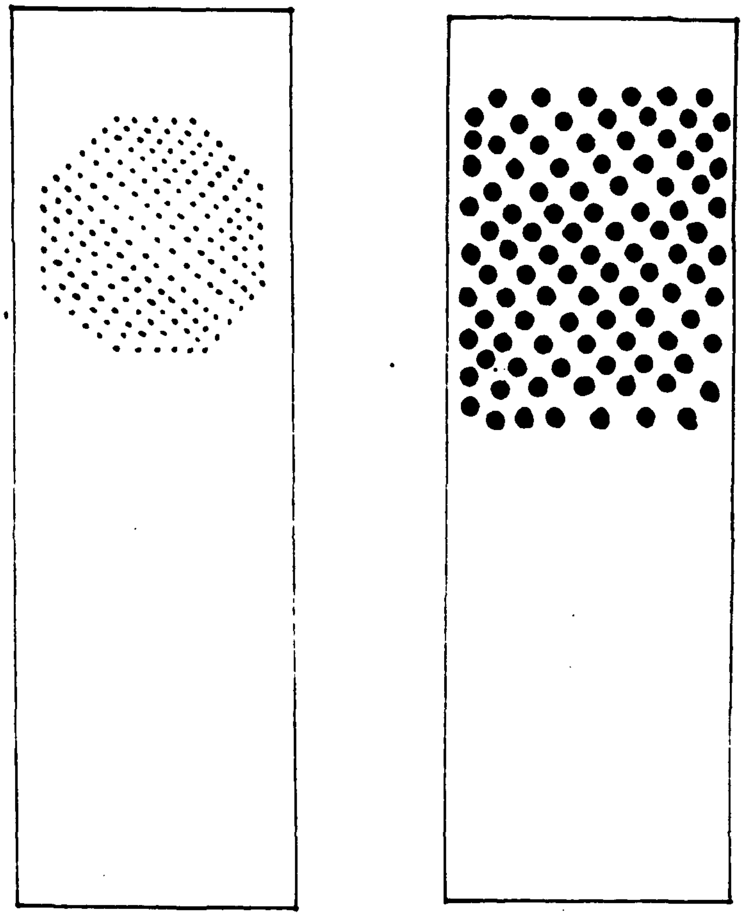
17. Divide average count rate in step 15.b by source B calibrated activity: .995

18. Divide average count rate in step 15.c by source C calibrated activity: .963

19. Divide average count rate in step 15.d by source D calibrated activity: 1.010

* Readings taken with attenuator K-2

Alpha Particle Attenuators used with the AN/UDM-6



K-1 ATTENUATOR　　K-2 ATTENUATOR

Figure 7

Attenuators

III. LINEARITY TEST

A. Criteria:

Response of the equipment shall be linear. Instrument readings at any point within the upper eighty percent of the 0 to 1,000 CPM range, and the upper ninety percent of all other ranges shall be within ten percent (plus or minus) of the readings caused by a known concentration of Plutonium.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. Calibrated Attenuators K-1 and K-2.

C. Test Procedure

1. Low Range (0 to 1,000 CPM)

a. Record the date, the serial numbers of the radiacmeter, the alpha probe, the calibrator, the 10^3 CPM calibrator source, and the calibrator's calibration date in the indicated spaces on the data sheet. Record the calibrated count rate for the 10^3 calibrator source in the indicated space on the data sheet. Place the calibrated AN/PDR-77 in the total count mode, and set the time interval to five minutes. With no source in the fixture, place the probe in the calibration fixture, and take five 5 minute background counts. Record them on the data sheet (Step 1). Average the background counts and record the average on the data sheet (Step 2).

b. Place the 10^3 CPM source from the AN/UDM-6 in the calibration fixture, and take five 5 minute counts. Record each 5 minute count on Step 3 of the data sheet. Average the five counts, and record this value on Step 4 of the data sheet. Divide this by five, and record this value on Step 5 of the data sheet.

c. Take the result of Step 5 of the data sheet and divide by the calibrated activity of the source. Record this result on Step 6 of the data sheet.

d. Repeat step C.1.b above, using the K-1 Attenuator. Record the results on steps 7, 8, and 9 of the data sheet.

e. Take the result of step 9 in the data sheet, divide by the calibrated attenuated activity of the source, and record this result on step 10 of the data sheet.

f. Repeat step C.1.b above, using the K-2 Attenuator. Record the results on steps 11, 12, and 13 of the data sheet.

g. Take the result of step 13 on the data sheet, divide by the calibrated attenuated activity of the source, and record this result on step 14 of the data sheet.

h. The results of steps 6, 10, and 14 on the data sheet shall not be less than 0.90 or greater than 1.10. If all three ratios do not fall within this range, the instrument has failed the test.

2. High Range (10^3 to 10^6 CPM)

a. Record the date, the serial numbers of the radiacmeter, the alpha probe, the calibrator, and each of the four calibrator sources, and the calibrator's calibration date in the indicated spaces on the data sheet. Record the calibrated count rate for each of the four calibrator sources in the indicated spaces on the data sheet. Place the calibrated AN/PDR-77 in the total count mode, and set the time interval to five minutes.

b. Place the 10^4 CPM source from the AN/UDM-6 in the calibration fixture, and take five 5 minute counts. Record each 5 minute count on step 1 of the data sheet. Average the five counts, and record this value on step 2 of the data sheet. Divide this by five, and record this value on step 3 of the data sheet.

c. Take the result of step 3 and divide by the calibrated activity of the source. Record this result on step 4 of the data sheet.

d. Repeat steps C.2.b and C.2.c with the 10^5 source in the calibration fixture. Record these values on steps 5 to 8 on the data sheet.

e. Reset the counting interval to 48 seconds. Repeat steps C.2.b and C.2.c with the 10^6 source in the calibration fixture. Record these values on steps 9 and 10 of the data sheet. Take the ratio of the average count to 890,818, and record this value on step 11 of the data sheet.

LINEARITY TEST (Continued)

f. Place the instrument in the ratemeter mode. Repeat steps C.2.d and C.2.e. Record these values on the data sheet. (Steps 12a to 12f)

g. The results of steps C.2.c, C.2.d, and C.2.e shall not be less than 0.90 or greater than 1.10. If all three ratios do not fall within this range, the instrument has failed the test.

DATA SHEET

Type Test: LINEARITY (LOW RANGE). DATE: 26 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
AP1559	1376	K-3	54.1
AP1559	1376	K-2	465.1

Test Data

1. Five 5 minute background counts: 7, 8, 7, 6, 7
2. Average background counts: 7
3. Five 5 minute counts using the 10^3 CPM source: 6.86K, 6.73K, 6.66K, 6.811K, 6.75K
4. Average the readings: 6.67 K
5. Divide the average reading by five: 1.35K CPM
6. Divide the above result by the calibrated activity of the 10^3 CPM source: .98
7. Five 5 minute counts using the 10^3 CPM source with the K-3 attenuator: 258, 295, 280, 273, 280
8. Average the readings: 277.2 Subtract background: 270.2
9. Divide the average reading by five: 54.04
10. Divide the above result by the calibrated attenuated activity of the 10^3 CPM source: .99

DATA SHEET

Type Test: LINEARITY (LOW RANGE) (Continued). DATE: 3 DEC 91

Probe S/N: A-2

11. Five 5 minute counts using the 10^3 CPM source with the K-2 attenuator: 2.35 K, 2.31 K, 2.28 K, 2.28 K, 2.15 K

12. Average the readings: 2.27 K Subtract background: 2267

13. Divide the average reading by five: 453.4

14. Divide the above result by the calibrated attenuated activity of the 10^3 CPM source: .98

DATA SHEET

Type Test: LINEARITY (HIGH RANGE). DATE: 20 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: AP094001 (A-1)

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P1559	1376		
B P1482	11799		
C P1907	121560		
D P2372	1113522	K-2	376370

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0

Test Data

1. Five 5 minute counts using the 10^4 CPM source: 58.9K, 58.8K, 59.9K 59.1K, 59.3K

2. Average 5 minute count using the 10^4 CPM source: 59.2 K

3. Average 5 minute count using the 10^4 CPM source, divided by five: 11.84 K CPM

4. Above result divided by the calibrated activity of the 10^4 CPM source: 1.00

5. Five 5 minute counts using the 10^5 CPM source: 611 K, 612K, 609K, 610K, 611K

6. Average 5 minute count using the 10^5 CPM source: 610.6 K

7. Average 5 minute count using the 10^5 CPM source, divided by five: 122.1 K CPM

8. Above result divided by the calibrated activity of the 10^5 CPM source: 1.01

DATA SHEET

Type Test: LINEARITY (HIGH RANGE) (Continued). DATE: 20 NOV 91

Probe S/N: A-1

9. Five 48 second counts using the 10^6 CPM source: 828K, 831K, 824K, 826K, 827K

10. Average 48 second count using the 10^6 CPM source: 827.2K

11. Above result divided by the calibrated count of 890,818 CPM: .929

12. Place the instrument in the ratemeter mode.

    A. Take five count rate readings using the 10^5 CPM source with no attenuator: 120K, 122K, 121K, 122K, 120K

    B. Average the readings: 121K

    C. Divide the above result by the calibrated activity of the source: .995

    D. Take five count rate readings using the 10^6 CPM source with the K-2 (.380) attenuator: 378K, 376K, 375K, 379K, 381K

    E. Average the readings: 377.8K

    F. Divide the above result by the calibrated attenuated activity of the 10^6 CPM source with attenuator K-2: 1.00

DATA SHEET

Type Test: LINEARITY (LOW RANGE). DATE: 20 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P1559	1376	K-1	26.8
A P1559	1376	K-2	465.1

Test Data

1. Five 5 minute background counts: 7, 7, 7, 7, 6
2. Average background counts: 6.8
3. Five 5 minute counts using the 10^3 CPM source: 6.77K, 6.88K, 6.82K, 6.93K, 6.90K
4. Average the readings: 6.86 K
5. Divide the average reading by five: 1372 CPM
6. Divide the above result by the calibrated activity of the 10^3 CPM source: .997
7. Five 5 minute counts using the 10^3 CPM source with the K-1 attenuator: 116, 155, 135, 145, 155
8. Average the readings: 141.2 Subtract background: 134.14
9. Divide the average reading by five: 25.46 CPM
10. Divide the above result by the calibrated attenuated activity of the 10^3 CPM source: .95

DATA SHEET

Type Test: LINEARITY (LOW RANGE) (Continued). DATE: 20 NOV 91

Probe S/N: A-1

11. Five 5 minute counts using the 10^3 CPM source with the K-2 attenuator: 2.28K, 2.39K, 2.40K, 2.30K, 2.38K

12. Average the readings: 2.35K Subtract background: 2.35K

13. Divide the average reading by five: 470 CPM

14. Divide the above result by the calibrated attenuated activity of the 10^3 CPM source: 1.01

DATA SHEET

Type Test: LINEARITY (HIGH RANGE). DATE: 22 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P1559	1376		
B P1482	11799		
C P1907	121560		
D P2372	1113522	K-2	376370

Mode: Ratemeter___ Scalar X Preset Time Interval (Min): 5.0

Test Data

1. Five 5 minute counts using the 10^4 CPM source: 60.1K, 59.6K, 59.4K, 60.5K, 59.8K

2. Average 5 minute count using the 10^4 CPM source: 60.0 K

3. Average 5 minute count using the 10^4 CPM source, divided by five: 12.0 K

4. Above result divided by the calibrated activity of the 10^4 CPM source: 1.02

5. Five 5 minute counts using the 10^5 CPM source: 600K, 600K, 600K, 597K, 610K

6. Average 5 minute count using the 10^5 CPM source: 601.4 K

7. Average 5 minute count using the 10^5 CPM source, divided by five: 120.28 K CPM

8. Above result divided by the calibrated activity of the 10^5 CPM source: .989

DATA SHEET

Type Test: LINEARITY (HIGH RANGE) (Continued). DATE: 27 Nov 91

Probe S/N: A-2

9. Five 48 second counts using the 10^6 CPM source: 843K, 834K, 832K, 824K, 836K

10. Average 48 second count using the 10^6 CPM source: 833.8 K

11. Above result divided by the calibrated count of 890,818: .936.

12. Place the instrument in the ratemeter mode.

   A. Take five count rate readings using the 10^5 CPM source with no attenuator: 117K, 118K, 117K, 118K, 119K

   B. Average the readings: 117.8 K CPM

   C. Divide the above result by the calibrated activity of the source: .969

   D. Take five count rate readings using the 10^6 CPM source with the K-2 attenuator: 375K, 372K, 367K, 368K, 363K

   E. Average the readings: 369K

   F. Divide the above result by the calibrated attenuated activity of the 10^6 CPM source with attenuator K-2: .981

IV. ENERGY DETECTION THRESHOLD TEST

A. Criteria:

The alpha energy threshold for detection shall be 3 MeV or less at the surface of the probe. The equipment shall be sensitive to alpha particles of all energies above this threshold.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. Threshold Energy Detection Fixture. (See figure 8)
4. Calibrated Barometer.

C. Test Procedure

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the calibrator, each of the four calibrator sources, the calibrator's calibration date, and the barometric pressure in the indicated spaces on the data sheet.

2. Place the 10^3 CPM source from the AN/UDM-6 in the calibration fixture. Place the calibrated AN/PDR-77 in the count rate mode. Turn on the Radiacmeter, and place the alarm switch in the "chirp" position.

3. Place the alpha probe on its side in the calibrated energy detection threshold fixture, so that the segment #5 of the probe face is directed towards the 10^3 CPM source. Slowly move the alpha source toward the probe, using the calibrated distance measuring gauge which is part of the fixture. (See figure 8)

4. Listen for the first "chirp" sounds indicating that the source has reached the distance from the probe face that allows only the most energetic alpha particles (5.1 MeV) to be detected. Record this distance on the data sheet. Repeat steps 3 and 4 for all the remaining segments, and record the results on the data sheet.

5. Using the enclosed graph of alpha particle residual energy as a function of air thickness, determine the residual energy for the distance measured in step 4 above. (See figure 9)

6. This residual energy is the minimum detectable energy threshold of the probe. Record this value on the data sheet.

7. If this energy level is not less than or equal to 3 MeV, the instrument has failed the test.

DATA SHEET

Type Test: ENERGY THRESHOLD. DATE: 25 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Barometric Pressure: 1023 m bars

Mode: Ratemeter X Scalar __ Preset Time Interval (Min): ____

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
AP1559	1376		

Test Data

1. Distance at which chirping first begins: 1.027", .987" (Segment #5)
2. Residual Alpha Energy (MeV) for above distance, utilizing figure 9:
   2.05, 2.2 MeV (Segment #5)
3.

Segment #	Distance (inches)	Residual Energy (MeV)
1	.795	2.80
2		
3		
4	.905	2.50
5	1.027, .987	2.05, 2.2
6	.852	2.68
7	1.09	1.80
8	.832	2.75
9		

Average Energy: ____ MeV

DATA SHEET

Type Test: ENERGY THRESHOLD. DATE: 25 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Barometric Pressure: 765 mm Hg.

Mode: Ratemeter X Scalar___ Preset Time Interval (Min):_______

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
AP1559	1376		

Test Data

1. Distance at which chirping first begins: 1.067 (Segment #5)

2. Residual Alpha Energy (MeV) for above distance, utilizing figure 9:

   1.86 MeV (Segment #5)

3.

Segment #	Distance (inches)	Residual Energy (MeV)
1	.907	2.47
2	.977	2.23
3	.927	2.40
4	.987	2.20
5	1.067	1.86
6	.937	2.35
7	.947	2.30
8	.967	2.25
9	.927	2.40

Average Energy: 2.27 MeV

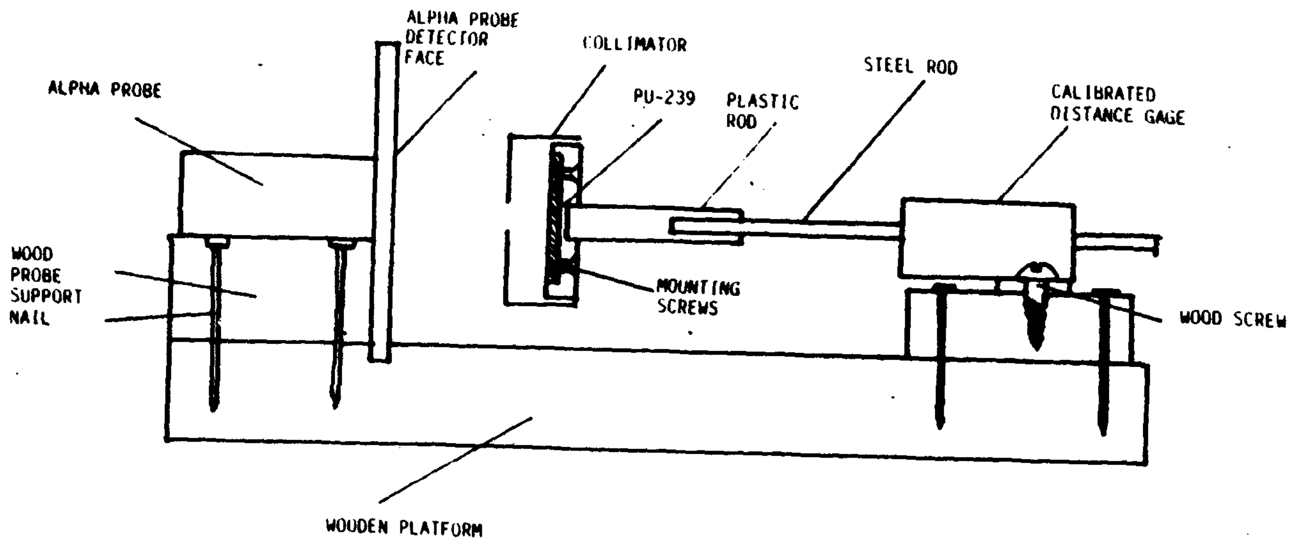


Figure 8

Threshold Energy Detection Fixture

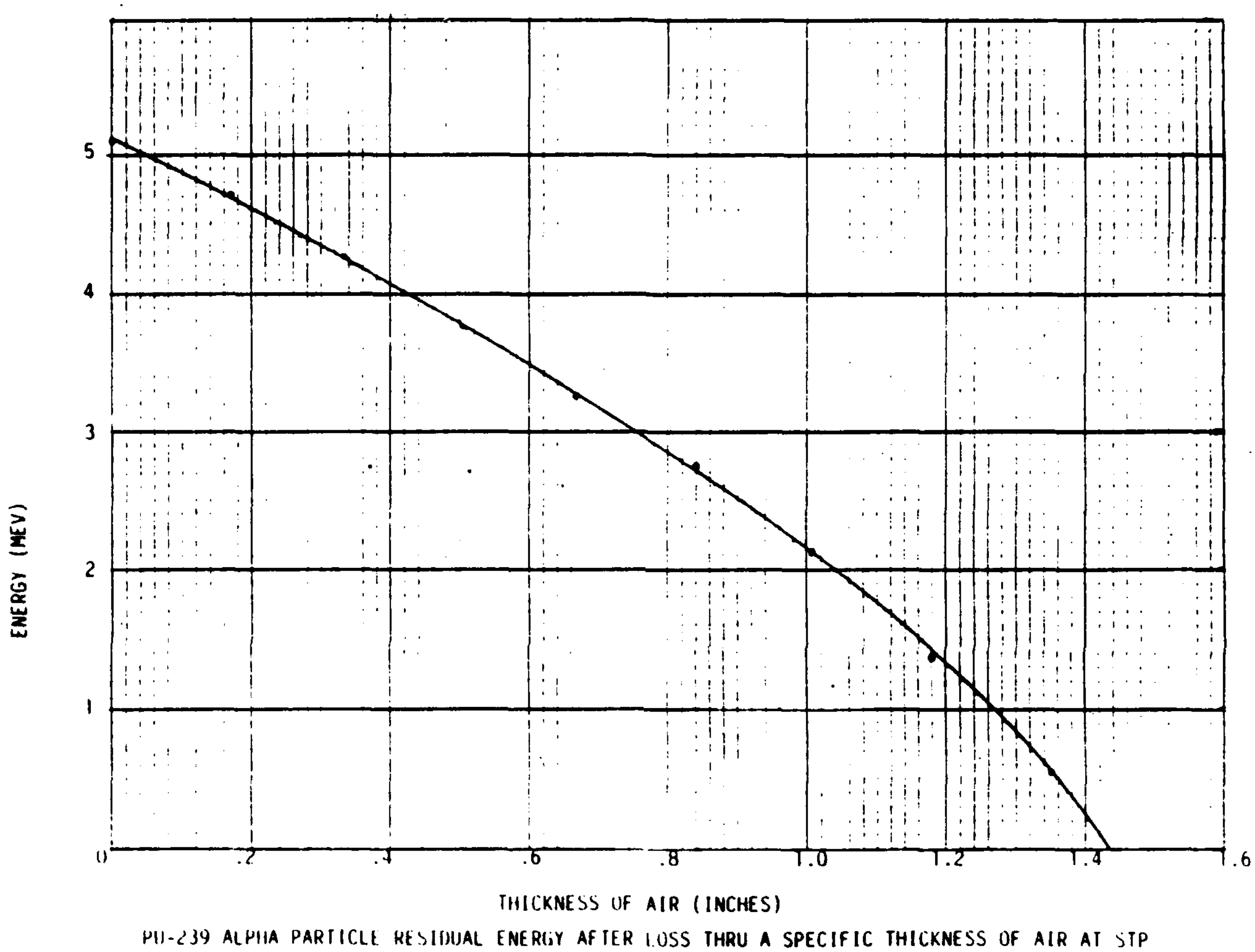


Figure 9

Alpha Particle Residual Energy - Pu^{239}

V. GAMMA RESPONSE TEST

A. Criteria:

The equipment's ability to detect alpha radiation shall not be significantly affected by other forms of ionizing radiation. The gamma response of the the instrument shall not exceed 25 CPM per mR/hr of gamma radiation at the location of the instrument, for a gamma field of up to 1 R/hr resulting from fissioned nuclear weapons material (gamma energies approximated by Cesium 137). The instrument's response to gamma radiation must not exceed 25,000 CPM.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. Calibrated Cs^{137} source with calibrated range.

C. Test Procedure - Gamma Sensitivity

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the Cs^{137} calibrator, the calibrated activity of the 10^3 CPM source, and the calibrator's calibration date in the indicated spaces on the data sheet.

2. With the Cs^{137} calibrator aperture closed, determine the distance down the range where the gamma dose rate is 1 R/hr. Put the calibrated AN/PDR-77 in the count rate mode, turn it on, and tape the 10^3 CPM source to the probe face. Place the probe at this location, with the face turned towards the calibrator. Record the count rate with the the Cs^{137} calibrator aperture shut on the data sheet.

3. Retire to a safe position and open the calibrator aperture. Observe the count rate shown on the radiacmeter display, and record this value on the data sheet.

4. If the observed count rate is greater than 25,000 CPM, the instrument has failed the test.

5. Close the Cs^{137} calibrator aperture and retrieve the calibrated AN/PDR-77.

D. Test Procedure - Gamma Dose Rate Dependence

1. Place the An/PDR-77 into the count rate mode. Mount the probe securely on a moveable platform on a calibrated track in front of a Cs-137 calibrated gamma source. The calibrator aperture is initially shut.

2. Turn the AN/PDR-77 on, and locate the moveable platform at a point where the gamma dose rate will be μ1 R/hr. Measure the distance from the source to the detector face.

3. Carefully tape the calibrated 10^3 alpha source from the AN/UDM-6 to segment #2 of the detector face. Record the count rate on the data sheet.

4. Open the gamma source aperture, and record the observed count rate, as displayed on the radiacmeter, on the data sheet. Close the gamma source aperture.

5. Move the platform with the AN/PDR-77 to a new position closer to the gamma source, and repeat steps 4 and 5, until the count rate falls to 100 CPM or less.

6. Plot the recorded data on a graph. (See figure 10)

<u>DATA SHEET</u>

Type Test: GAMMA RESPONSE. DATE: 20 NOV 91

Gamma Calibrator, Type and S/N: AN/UDM-1A, Cs-137, SN CS-02

Calibration date: 4 DEC 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Mode: Ratemeter X Scalar ___ Preset Time Interval (Min): ______

A. Test Data - Gamma Sensitivity

1. Cs^{137} gamma dose rate: 1.00 R/hr.

2. Observed count rate (with calibrator closed): 1340 CPM

3. Observed count rate (with calibrator open): 1340 CPM

4. Increase in count rate due to 1 R/hr gamma: 0 CPM

B. Test Data - Gamma Dose Rate Dependence

Point #	Dose Rate (R/hr)	Distance (cm)	Count Rate (CPM)
1	0	208	1.21 K
2	5	208	1.11 K
3	6.6	180	870
4	7.2	170	770
5	7.8	160	680
6	8.4	150	560
7	9.5	130	365
8	9.9	120	320
9	11	110	170
10	16	100	60-80 ERRATIC
11	20	95	0-120 mostly ZERO
12			
13			

DATA SHEET

Type Test: GAMMA RESPONSE. DATE: 3 DEC 91

Gamma Calibrator, Type and S/N: AN/UDM-1A, Cs-137, SN CS-02

Calibration date: 4 DEC 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Mode: Ratemeter X Scalar __ Preset Time Interval (Min): __

A. Test Data - Gamma Sensitivity

1. Cs^{137} gamma dose rate: 1.00 R/hr.
2. Observed count rate (with calibrator closed): 1.06 K CPM
3. Observed count rate (with calibrator open): 1.06 K CPM
4. Increase in count rate due to 1 R/hr gamma: 0 CPM

B. Test Data - Gamma Dose Rate Dependence (NOT CONDUCTED)

Point #	Dose Rate (R/hr)	Distance (cm)	Count Rate (CPM)
1			
2			
3			
4	(TEST	NOT CONDU	CTED)
5			
6			
7			
8			
9			
10			
11			
12			
13			

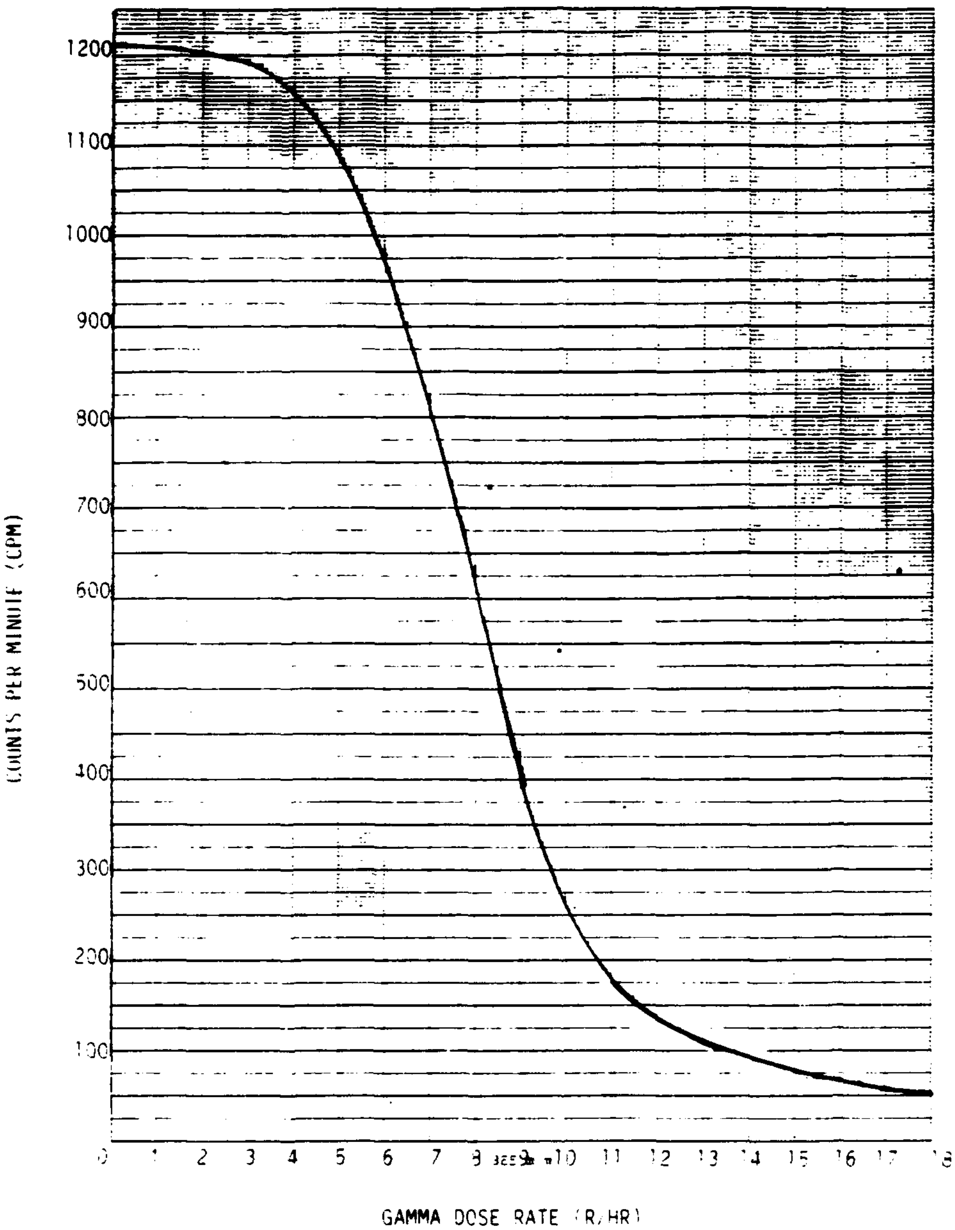


Figure 10

Gamma Dose Rate Dependence

VI. BATTERY LIFE TEST

A. Criteria:

The equipment shall operate as specified for at least fifty hours per set of batteries, including four hours intermittent operation of the internal illumination of the radiacmeter display. Changing of the batteries shall not require recalibration of the equipment. It should be possible to change batteries using only a screwdriver.

B. Required Equipment.

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. Six (6) BA-3090/U nine volt nonrechargeable batteries.
4. Screwdriver.

C. Test Procedure.

1. Battery Life.

(a) Record the date, the serial numbers of the radiacmeter, the alpha probe, the AN/UDM-6 calibrator, the calibrated activity of the 10^4 CPM source from the AN/UDM-6, and the calibrator's calibration date in the indicated spaces on the data sheet.

(b) Turn the calibrated AN/PDR-77 on, place it in the ratemeter mode, and turn the display illumination on. Place the 10^4 CPM source from the AN/UDM-6 in the calibration fixture.

(c) Place the AN/PDR-77 in the calibration fixture, and record the time and the count rate on the data sheet.

(d) Allow the unit to operate with the light on for four hours. At the end of four hours, record the count rate on the data sheet, turn off the display illumination, and allow the unit to continue operating.

(e) Continue to monitor the unit periodically, recording the time, count rate, and battery voltage, noting the appearance of the flashing arrow display, indicating low batteries.

(f) Continue to monitor the unit periodically, until normal operation ceases. Record this time on the data sheet.

(g) If the total elapsed time from step c.1(b) to step c.1(f) is less than fifty hours, the unit has failed the test.

BATTERY LIFE TEST (Continued)

2. Effect on Calibration.

a. Turn the unit off, and open the battery box at the rear of the radiacmeter casing. Remove the batteries inside, and replace with three fresh batteries. Repeat the calibration procedure done earlier to verify that the unit is still calibrated. If the new slide switch settings calculated are different from those calculated earlier, the unit has failed the test.

DATA SHEET

Type Test: BATTERY LIFE.

DATE: 23 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P1559	1376		
B			
C			
D			

Mode: Ratemeter ✓ Scalar__ Preset Time Interval (Min):____

Test Data

1. Battery Life. 12/17/91

   a. Initial Time: 10 AM Initial Count Rate: 123 K CPM

   b. Record periodic monitoring time and count rates below. Use a separate sheet if necessary.

TIME (HRS)	COUNT RATE (CPM)	BATTERY VOLTAGE
0	123 K	9.3 V
25	122 K	8.0 V
50	123 K	7.65 V
75	121 K	7.0 V
85	117 K	6.3 V
91	110 K	5.5 V

   c. Time at which radiacmeter indicates low battery (flashing arrow). 82 HRS Scale Light ON 5 HOURS

DATA SHEET

Type Test: CALIBRATION EFFECT. DATE: 23 DEC 91

Probe S/N: A-2

a. Remove depleted batteries (check) ✓

b. Repeat calibration procedure (check) ✓

c. Compare results of switch position calculation with those on original calibration data sheet:

Original settings for switches H and J. H: 4 J: 5

Calculated settings for switches H and J. H: 4 J: 5

If the results differ between the two calibrations, the unit has failed the test.

DATA SHEET

Type Test: BATTERY LIFE. DATE: 8 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A			
B P1482	11799		
C			
D			

Mode: Ratemeter X Scalar__ Preset Time Interval (Min):____

Test Data

1. Battery Life. 12/3/91

   a. Initial Time: 13:45 Initial Count Rate: 11.8 K CPM

   b. Record periodic monitoring time and count rates below. Use a separate sheet if necessary.

TIME (HRS)	COUNT RATE (CPM)	BATTERY VOLTAGE
0	11.8 K	9.4
34	11.9 K	8.5
58	12.0 K	8.0
86	11.7 K	7.85
115	11.5 K	4.9
117	10.8 K	4.6

   c. Time at which radiacmeter indicates low battery (flashing arrow). 93 HRS

DATA SHEET

Type Test: CALIBRATION EFFECT. DATE: 8 DEC 91

Probe S/N: A-1

a. Remove depleted batteries (check) ✓

b. Repeat calibration procedure (check) ✓

c. Compare results of switch position calculation with those on original calibration data sheet:

Original settings for switches H and J. H: 4 J: 5

Calculated settings for switches H and J. H: 4 J: 5

If the results differ between the two calibrations, the unit has failed the test.

VII. RESPONSE TIME TEST

A. Criteria:

The equipment shall be capable of operating with the required accuracy within two minutes after being turned on following a period of inactivity of at least 60 minutes.

B. Required Equipment.

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.

C. Test Procedure.

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the AN/UDM-6 calibrator, the calibrated activity of the 10^5 CPM source from the AN/UDM-6, and the calibrator's calibration date in the indicated spaces on the data sheet.

2. Turn the calibrated AN/PDR-77 on and place it in the ratemeter mode. Place the 10^5 CPM source from the AN/UDM-6 in the calibration fixture.

3. Place the probe into the calibration fixture, and record the count rate on the data sheet (Step 1). It should be within ±10% of the calibrated activity of the 10^5 CPM source from the AN/UDM-6. Record the percentage difference on the data sheet. (Step 2)

4. Turn off the unit, and remove the probe form the fixture. Record the time at which this is done on the data sheet. (Step 3)

5. Wait at least sixty minutes. Record the time, on the data sheet (Step 4), place the probe in the calibrator, and turn the unit on. Wait a further two minutes, and record the count rate as displayed on the radiacmeter on the data sheet (Step 5).

6. If the dose recorded in step C.5 above is not within ±10% of the calibrated activity of the 10^5 CPM source from the AN/UDM-6, the instrument has failed the test.

DATA SHEET

Type Test: Response Time. DATE: 26 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A			
B			
C P1907	121560		
D			

Mode: Ratemeter X Scalar___ Preset Time Interval (Min):______

Test Data

1. Initial count rate reading: 119K CPM
2. Percentage difference between initial count rate reading and calibrated count rate of source: -2.1 %
3. Time unit is turned off: 14:50
4. Time unit is turned on: 15:50
5. Second count rate reading: 120K CPM
6. Percentage difference between second count rate reading and calibrated count rate of source: -1.3 %

DATA SHEET

Type Test: Response Time. DATE: 3 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A			
B			
C P1907	121560		
D			

Mode: Ratemeter X Scalar___ Preset Time Interval (Min):______

Test Data

1. Initial count rate reading: 112 K CPM
2. Percentage difference between initial count rate reading and calibrated count rate of source: -7.43 %
3. Time unit is turned off: 14:05
4. Time unit is turned on: 15:05
5. Second count rate reading: 119 K CPM
6. Percentage difference between second count rate reading and calibrated count rate of source: -2.11 %

VIII. STABILITY TEST

A. Criteria:

The equipment shall be zero stable, and shall not drift beyond the specified accuracy over the battery operating life. Replacement of the batteries shall restore the reading to the limits allowed under the criteria for reproducibility, with recalibration.

B. Required Equipment.

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.

C. Test Procedure.

1. Stability.

    1. Utilize the count rate data from the Battery Test Procedure to verify that the criteria has been met.

2. Calibration.

    1. Utilize the data taken during the calibration check performed following the Battery Life Test to verify that the criteria has been met.

DATA SHEET

Type Test: STABILITY. DATE: 3 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Test Data

1. Stability: count rate readings stayed within specified accuracy limits during battery life test (check) ✓
2. Calibration: Battery replacement restore readings to specified accuracy (check) ✓

DATA SHEET

Type Test: STABILITY. DATE: 3 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Test Data

1. Stability: count rate readings stayed within specified accuracy limits during battery life test (check) ✓

2. Calibration: Battery replacement restore readings to specified accuracy (check) ✓

IX. LIGHT LEAK TEST

A. Criteria:

The Alpha Probe shall have no light leaks.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. Opaque black cloth.

C. Test Procedure.

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the AN/UDM-6 calibrator, the calibrated activity of the 10^3 CPM source from the AN/UDM-6, and the calibrator's calibration date in the indicated spaces on the data sheet.

2. Turn on the AN/PDR-77, and place it in the count rate mode. Place the probe face up on a stable surface. Remove the 10^3 CPM source from the AN/UDM-6 bracket, and place it (face down) on one of the probe face's corner segments. Record the count rate on the data sheet.

3. Place the black cloth over the entire probe, making sure that no light can get in around the edges. Record the count rate on the data sheet.

4. Repeat steps 2 and 3 after placing the 10^3 CPM source on a diagonal corner segment. Record the count rate on the data sheet.

5. A substantial increase in the count rate indicates a light leak in the probe. If the covered and uncovered count rates differ by more than ±10%, the probe has failed the test.

DATA SHEET

Type Test: Light Leak Test. DATE: 11 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
AP1482	11799		

Mode: Ratemeter X Scalar___ Preset Time Interval (Min): ______

Test Data

1. Uncovered count rate reading: 1.76 K CPM SEGMENT #1
2. Covered count rate reading: 7.43 K CPM SEGMENT #1
3. Percentage difference between uncovered and covered count rate readings: 23.7 %
4. Uncovered count rate reading (diagonal segment): 1.43 K CPM
5. Covered count rate reading (diagonal segment): 6.84 K CPM
6. Percentage difference between uncovered and covered count rate readings: 20.9 %

DATA SHEET

Type Test: Light Leak Test. DATE: 11 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
AP1482	11799		

Mode: Ratemeter X Scalar__ Preset Time Interval (Min):____

Test Data

1. Uncovered count rate reading: 11.3 K CPM
2. Covered count rate reading: 11.3 K CPM
3. Percentage difference between uncovered and covered count rate readings: 0 %
4. Uncovered count rate reading (diagonal segment): 11.4 K CPM
5. Covered count rate reading (diagonal segment): 11.4 K CPM
6. Percentage difference between uncovered and covered count rate readings: 0 %

X. HIGH TEMPERATURE TEST (60°C).

A. Criteria:

The instrument shall be capable of operating with the required accuracy (±10% from 200 CPM to 999 KCPM) in climatic categories 1 through 6 in AR 70-38.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. Calibrated Environmental Chamber.

C. Test Procedure.

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the AN/UDM-6 calibrator, the calibrated activity of the 10^4 CPM source from the AN/UDM-6, and the calibrator's calibration date in the indicated spaces on the data sheet. Record the model, serial number, and calibration date of the environmental chamber in the indicated spaces on the data sheet.

2. Place the alpha probe inside the environmental chamber along with the calibration fixture and the 10^4 CPM source from the AN/UDM-6. The radiacmeter is left outside, with the coil cord run through one of the access ports in the chamber wall.

3. Connect the probe to the radiacmeter using the access port in the wall of the chamber. Turn the AN/PDR-77 on, and place it in the count rate mode. Record the count rate at ambient temperature in the indicated space on the data sheet.

4. Set the chamber controls for 60°C and turn the chamber on. Record the time in the indicated space on the data sheet.

5. After at least two hours at 60°C, and at intervals thereafter, record the time, temperature, and count rate in the indicated spaces on the data sheet.

6. If the difference between the first and last count rate readings is greater than ±10%, the probe has failed the test.

DATA SHEET

Type Test: High Temperature (60°C). DATE: 26 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Chamber Model: TENNEY

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
B P1482	11799		

Mode: Ratemeter X Scalar___ Preset Time Interval (Min):_______

Test Data

Time	Count Rate	Temperature (°C)
1 0837	11.7 K	(Ambient)
2 0857	11.7K	60°
3 0917	11.2K	60°
4 0950	11.0K	60°
5 1017	11.0K	60°
6 1118	11.3 K	60°
7		

1. Percentage difference between initial and final count rate readings: -3.4 %

DATA SHEET

Type Test: High Temperature (60°C). DATE: 26 NOV 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM994102 Probe S/N: A-2

Chamber Model: TENNEY

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
BP-1482	11799		

Mode: Ratemeter X Scalar ___ Preset Time Interval (Min): ______

Test Data

Time	Count Rate	Temperature (°C)
1 11:20	11.2 K	(Ambient)
2 13:20	10.2 K	60°
3 14:00	10.3 K	60°
4 15:20	10.2 K	60°
5 16:20	10.2 K	60°
6		
7		

1. Percentage difference between initial and final count rate readings: -8.9 %

XI. DETECTOR AREA RESPONSE TEST

A. Criteria:

The sensitivity of the probe shall be uniform across the face of the detector.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. Opaque Black Cloth.

C. Test Procedure - Average Accuracy per Area Segment

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the AN/UDM-6 calibrator, the calibrated activity of the 10^4 CPM source from the AN/UDM-6, and the calibrator's calibration date in the indicated spaces on the data sheet.

2. Place the alpha probe face up on a stable surface with the handle pointed towards the operator. Place the 10^4 CPM source from the AN/UDM-6 (face down) on segment 1 of the probe face. (See figure 5a)

3. Turn the AN/PDR-77 on, and place it in the count rate mode. Wait at least two minutes, and record the count rate in the indicated space on the data sheet. If a light leak is present, use the black cloth.

4. Repeat steps 2 and 3 for the remaining eight segments of the probe face, and record the count rate for each one in the indicated space on the data sheet.

5. Divide the count rate for each segment by that of the count rate for the 10^4 CPM calibration source, and record each ratio in the indicated space on the data sheet.

6. Average the nine ratios calculated in step 5. This average constitutes the average accuracy of each of the nine segments of the probe face, and the accuracy of the probe when used in a large area contamination field.

D. Test Procedure - Uniformity in Detection of Detector Face Area.

1. Collimate the 10^6 CPM calibration source using a hole approximately ¼ inch in diameter.

2. Place the Alpha Probe face up on a flat, level surface.

3. Turn on the AN/PDR-77, and place it in the count rate mode.

4. Place the collimated source at the locations shown in figure 12. Cover the probe with the black cloth. Record the count rate for each location on the data sheet.

5. Normalize the detected count rates at the various locations to the count rate measured at the center of segment #5. Record these ratios on the data sheet.

6. Graphically indicate the calculated ratio at the measured locations on the probe face area on figures 13 and 13a.

DATA SHEET

Type Test: Detector Area Response. DATE: 5 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
B P-1482	11799		
P-2372	1113522	Collimated	-

Mode: Ratemeter x Scalar___ Preset Time Interval (Min):________

A. Test Data - Average Accuracy per Segment Area

1. count Rates by segment:

Segment	Count Rate (CPM)	Segment	Count Rate (CPM)
1	11.2 K	2	12.7 K
3	11.3 K	4	13.5 K
5	15.3 K	6	13.1 K
7	11.9 K	8	12.7 K
9	11.7 K		

2. count Rate ratios by segment:

Segment	Count Rate Ratio	Segment	Count Rate Ratio
1	.949	2	1.076
3	.958	4	1.144
5	1.297	6	1.110
7	1.009	8	1.076
9	.992		

3. Add all count rate ratios and divide by nine: 1.068

DATA SHEET

Type Test: Area Response Probe S/N: A-1 DATE: 6 DEC 91

B. Test Data - Uniformity of Detection over the Face Area.

Location #	Count Rate (CPM)	Ratio	Normalized to location #12.
1	26.9 K		.614
2	32.1 K		.733
3	27.0 K		.616
4	23.7 K		.541
5	32.8 K		.749
6	36.7 K		.838
7	26.5 K		.605
8	32.0 K		.731
9	44.2 K		1.01
10	36.6 K		.836
11	38.4 K		.877
12	43.8 K		1.00
13	43.2 K		.986
14	30.2 K		.690
15	26.5 K		.605
16	37.2 K		.849
17	34.0 K		.776
18	24.5 K		.559
19	25.9 K		.591
20	30.0 K		.685
21	25.9 K		.591

DATA SHEET

Type Test: Detector Area Response.　　　　DATE: 5 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102　　Probe S/N: A-2

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
B P-1482	11799		
P-2372	1113522	Collimated	

Mode: Ratemeter X　Scalar___　　Preset Time Interval (Min):_______

A. Test Data - Average Accuracy per Segment Area

1. Count Rates by segment: (Black Cloth covered)

Segment	Count Rate (CPM)	Segment	Count Rate (CPM)
1	7.87 K	2	11.6 K
3	8.31 K	4	11.4 K
5	13.8 K	6	11.7 K
7	6.97 K	8	10.6 K
9	6.50 K		

2. Count Rate ratios by segment:

Segment	Count Rate Ratio	Segment	Count Rate Ratio
1	.667	2	.983
3	.704	4	.966
5	1.170	6	.992
7	.591	8	.898
9	.551		

3. Add all count rate ratios and divide by nine: 0.836

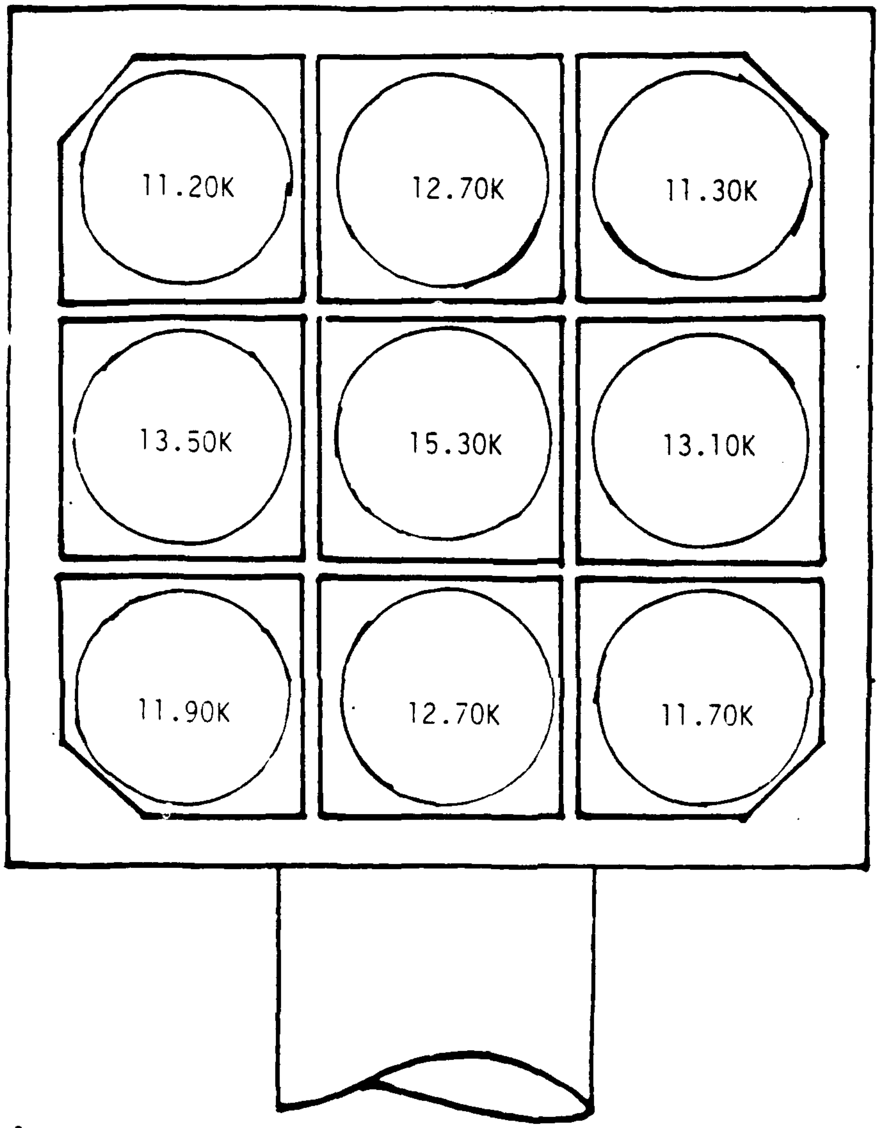
DATA SHEET

Type Test: Area Response. Probe S/N: A-2 DATE: 5 DEC 91

B. Test Data - Uniformity of Detection over the Face Area.

Location #	Count Rate (CPM)	Ratio	Normalized to location #12.
1	19.2 K		.608
2	25.0 K		.791
3	24.7 K		.782
4	17.2 K		.544
5	30.3 K		.959
6	25.0 K		.791
7	24.0 K		.760
8	25.0 K		.791
9	30.8 K		.975
10	42.0 K		1.33
11	37.0 K		1.17
12	31.6 K		1.00
13	44.6 K		1.41
14	31.2 K		.987
15	20.1 K		.636
16	31.9 K		1.01
17	30.1 K		.953
18	16.1 K		.510
19	17.9 K		.567
20	26.7 K		.845
21	12.6 K		.399

SN AP094001 (A-1)



Measured Count Rate for each segment area using calibrated AN/UDM-6 source P-1482 (11799 CPM)

Figure 11

Detector Segment Area Count Rate (Probe A-1)

SN AP094003 (A-2)

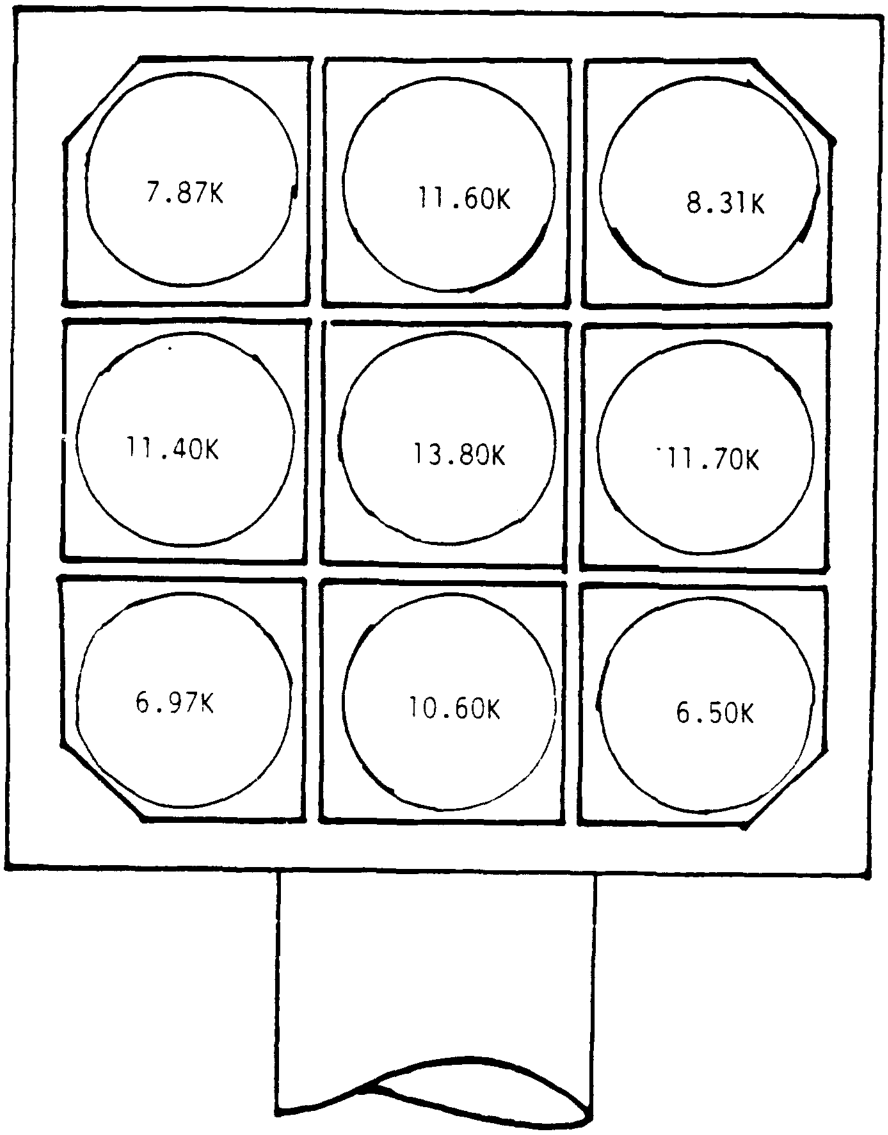
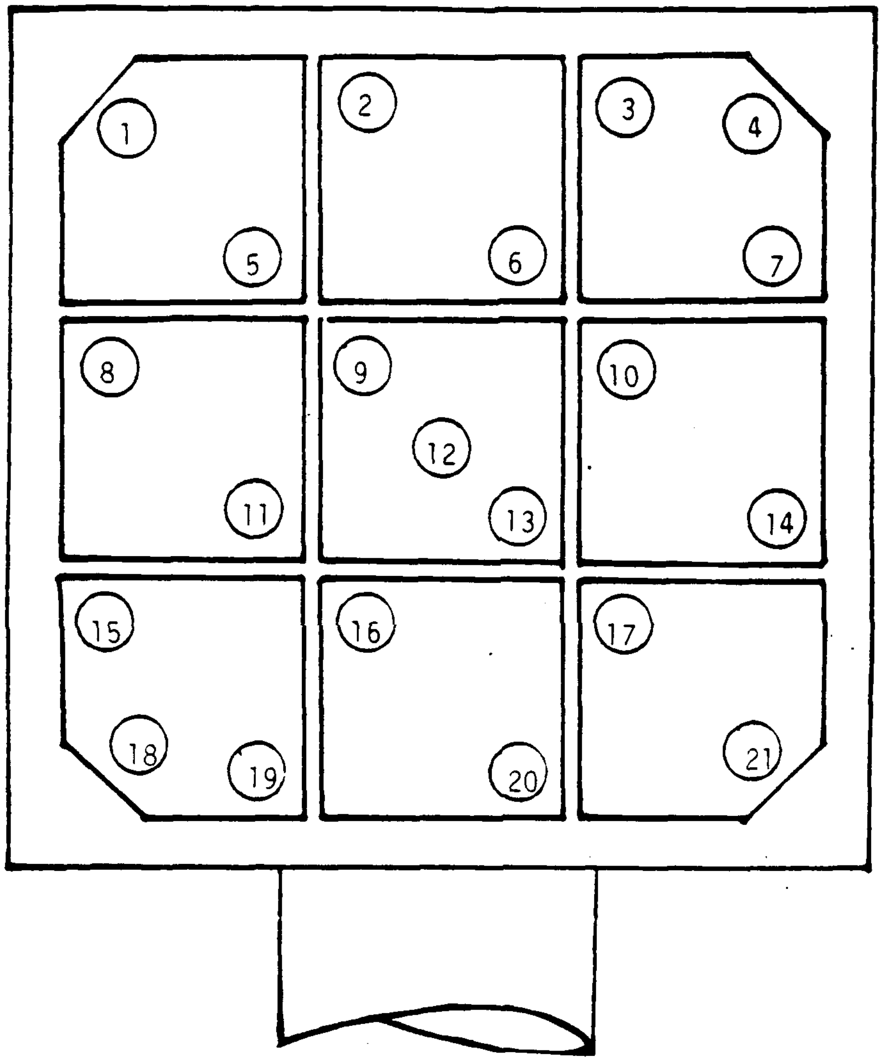


Figure 11a

Detector Segment Area Count Rate (Probe A-2)

Prototype Probe Face Segments
with Count Rate measurement locations

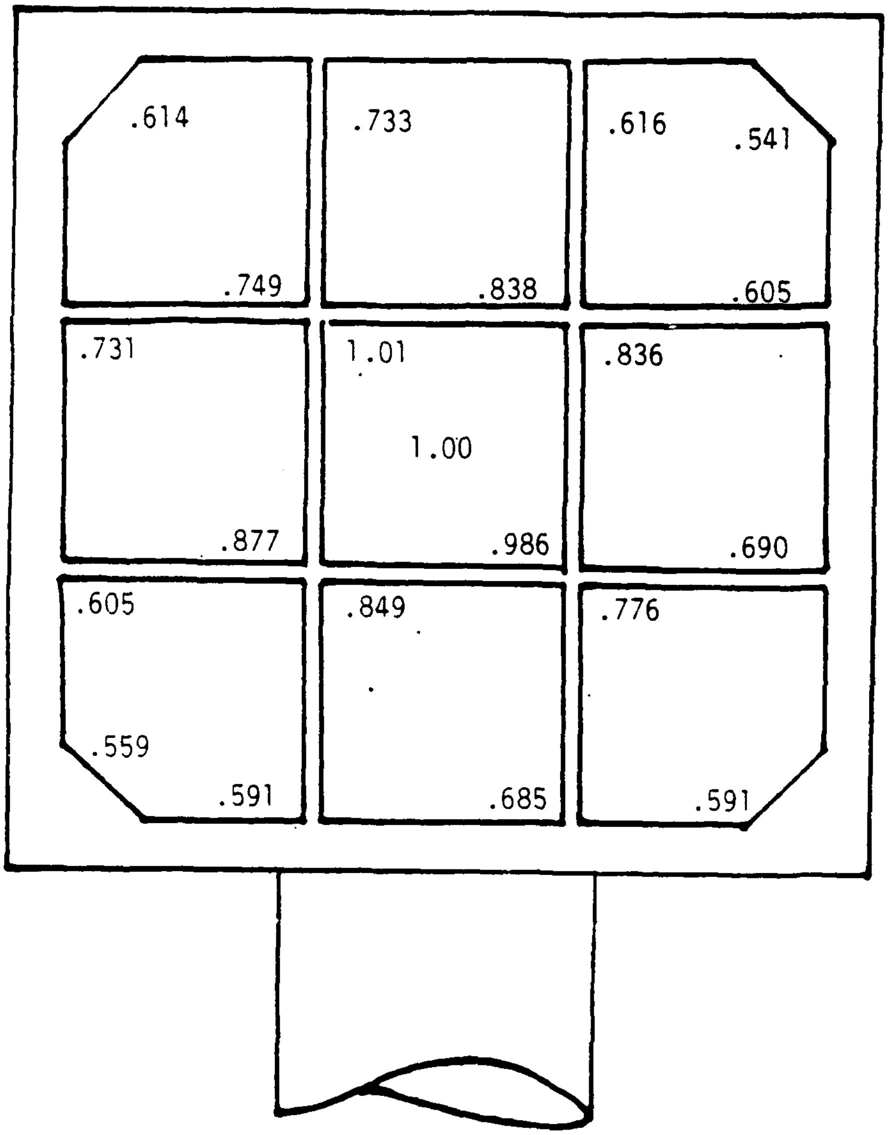


Locations of measurements made with collimated
AN/UDM-6 Alpha Source P-2372 (1,113,522 CPM)
to determine uniformity of detection

Figure 12

Detector Uniformity Measurement Locations

SN AP094001 (A-1)

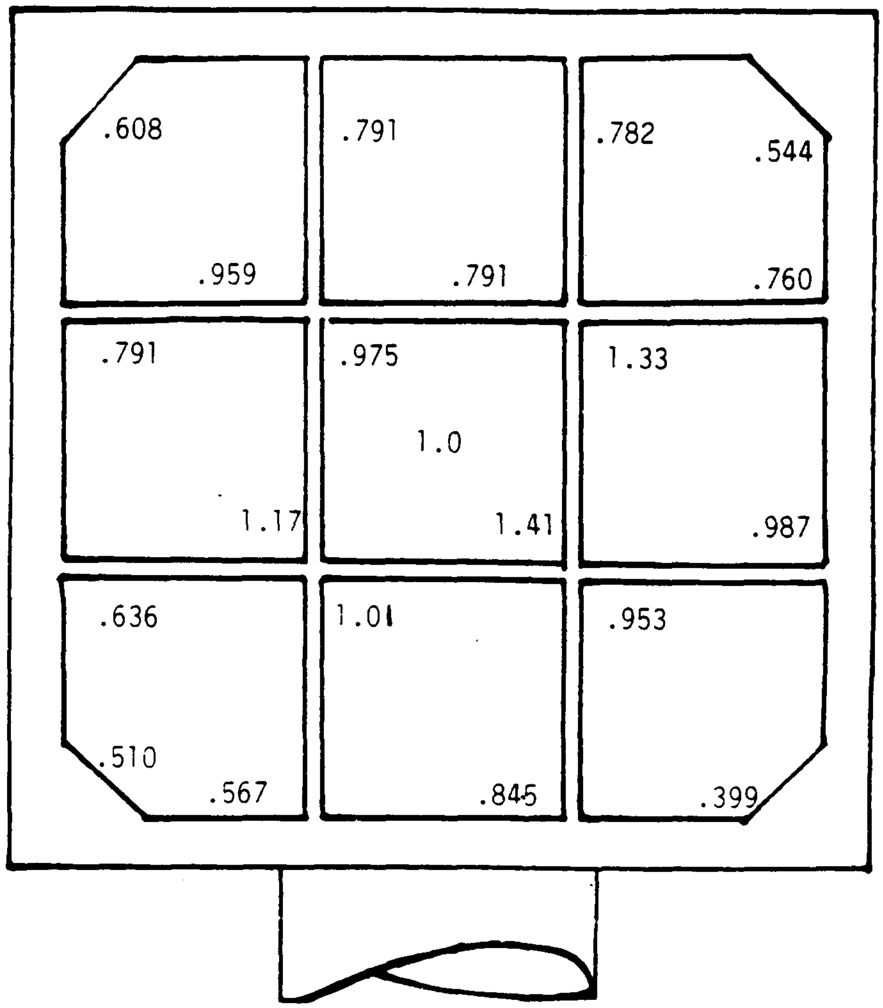


Uniformity of Detection
Measured Count Rate at specific locations, normalized to measured Count Rate at the center of the detector face area

Figure 13

Normalized Detector Uniformity Measurement (Probe A-1)

SN AP094003 (A-2)



Uniformity of Detection
Measured Count Rate at specific locations, normalized to measured Count Rate at the center of the detector face area

Figure 13a

Normalized Detector Uniformity Measurement (Probe A-2)

XII. LOW VOLTAGE EFFECT TEST

A. Criteria:

There is no explicit requirement for this test; however it is important to know the voltage level at which the reading becomes erratic.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. Calibrated DC Power Supply.

C. Test Procedure.

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the AN/UDM-6 calibrator, the calibrated activity of the 10^4 CPM source from the AN/UDM-6, and the calibrator's calibration date in the indicated spaces on the data sheet. Record the model, serial number, and calibration date of the power supply in the indicated spaces on the data sheet.

2. Remove the batteries from the AN/PDR-77, and connect the power supply directly to the terminals inside the battery enclosure.

3. Set the power supply for 9 VDC, and turn it on. Turn the AN/PDR-77 on, and place it in the count rate mode.

4. Place the probe face up on a stable surface. Place the 10^4 CPM source from the AN/UDM-2 face down on segment five of the probe face. Wait at least two minutes and record the count rate in the indicated space on the data sheet.

5. Lower the voltage 0.5 volts. Wait at least two minutes and record the count rate in the indicated space on the data sheet.

6. Repeat step 5 until the arrow on the display begins to flash. Record the count rate in the indicated space on the data sheet.

7. Continue with step 5 until the display becomes erratic.

DATA SHEET

Type Test: Low Voltage Effect. DATE: 3 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Power Supply Model: ____________ Power Supply S/N: ____________

Power Supply Calibration date: ____________

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
BP.1482	11799		

Mode: Ratemeter X Scalar ___ Preset Time Interval (Min): ________

Test Data

Voltage	Count Rate (CPM)	Voltage	Count Rate (CPM)
9.0	12.9 K	6.0	11.9 K
8.5	12.9 K	5.5	11.3 K
8.0	12.9 K	5.0	10.0 K
7.5	12.9 K	4.5	4.0 K ERRATIC
7.0	12.6 K	4.0	
6.5	12.4 K	3.5	

1. Voltage and count rate at which initial low voltage indication (flashing arrow) appears on display:

6.5 V / 12.4 K

2. Voltage and count rate at which display becomes erratic:

4.5 / 4.0 K

DATA SHEET

Type Test: Low Voltage Effect. DATE: 3 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Power Supply Model: ____________ Power Supply S/N: ____________

Power Supply Calibration date: ____________

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
BP-1482	11799		

Mode: Ratemeter X Scalar___ Preset Time Interval (Min):_______

Test Data

Voltage	Count Rate (CPM)	Voltage	Count Rate (CPM)
9.0	12.4	6.0	11.5
8.5	12.4	5.5	11.0
8.0	12.3	5.0	ERRATIC
7.5	12.2	4.5	
7.0	12.2	4.0	
6.5	12.2	3.5	

1. Voltage and count rate at which initial low voltage indication (flashing arrow) appears on display:

6.5 V / 12.2 K

2. Voltage and count rate at which display becomes erratic:

5.0 V / 10K

XIII. SYSTEM CURRENT DRAIN TEST

A. Criteria:

There is no explicit requirement for this test; however it is important to know the current drain for various operational modes of the AN/PDR-77.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. Calibrated Ampere Meter.
4. Three fresh BA-3090 Batteries

C. Test Procedure.

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the AN/UDM-6 calibrator, the calibrated activity of all four sources from the AN/UDM-6, and the calibrator's calibration date in the indicated spaces on the data sheet. Record the model, serial number, and calibration date of the ampere meter in the indicated spaces on the data sheet.

2. Replace the batteries within the AN/PDR-77 with the fresh batteries. Turn the AN/PDR-77 on, and place it in the count rate mode. Place the probe in the calibration fixture without an alpha source. After at least two minutes, record the current and the count rate on the data sheet.

3. Turn on the light and record the current on the data sheet. Turn the light off.

4. Place the 10^3 CPM source in the fixture, and replace the probe. Record the current on the data sheet.

5. Turn the "Audio" switch to the "chirp" position. Record the current on the data sheet.

6. Turn the "Audio" switch to the "alarm" position. Record the current on the data sheet.

7. Remove the probe from the test fixture, and replace the 10^3 source with the 10^5 source. Repeat steps 4, 5, and 6.

8. Remove the probe from the test fixture, and replace the 10^5 source with the 10^6 source. Repeat steps 4, 5, and 6.

9. Turn on the light, and set the "Audio" switch to the "chirp" position. Record the current on the data sheet.

DATA SHEET

Type Test: System Current Drain. DATE: 23 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM994103 Probe S/N: A-1

Ampere Meter Model:______ Ampere Meter S/N:______

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P1559	1376		-
B P1482	11799		
C P1907	121560		
D P2372	1113582		

Mode: Ratemeter X Scalar__ Preset Time Interval (Min):______

Test Data

1. No Source, Light off.

   Current: 9.15 MA Count Rate: 7 CPM

2. No Source, Light on.

   Current: 18.25 MA

3. 10^3 CPM source.

   Current: 10.10 MA

4. 10^3 CPM source, "chirp" on.

   Current: 11-13 MA

5. 10^3 CPM source, "alarm" on.

   Current: 17-26 MA

DATA SHEET

Type Test: System Current Drain (Continued) Date: 23 DEC 91

Probe S/N: A-1

6. 10^5 CPM source.

   Current: 10.1 mA

7. 10^5 CPM source, "chirp" on.

   Current: 16-25 mA

8. 10^5 CPM source, "alarm" on.

   Current: 17-26 mA

9. 10^6 CPM source.

   Current: 10.1 mA

10. 10^6 CPM source, "chirp" on.

    Current: 18-28 mA

11. 10^6 CPM source, "alarm" on.

    Current: 17-27 mA

12. 10^6 CPM source, light on, "chirp" on.

    Current: 25-37 mA

DATA SHEET

Type Test: System Current Drain. DATE: 23 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Ampere Meter Model:________ Ampere Meter S/N:________

Alpha Source S/N	Calibrated Activity(CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
A P-1559	1376		
B P-1482	11799		
C P-1907	121560		
D P-2372	1113522		

Mode: Ratemeter X Scalar___ Preset Time Interval (Min):______

Test Data

1. No Source, Light off.

   Current: 11.5 mA Count Rate: 7 CPM

2. No Source, Light on.

   Current: 21.8 mA

3. 10^3 CPM source.

   Current: 11.5 mA

4. 10^3 CPM source, "chirp" on.

   Current: 10.8 - 12.1 mA

5. 10^3 CPM source, "alarm" on.

   Current: 16 - 27 mA

DATA SHEET

Type Test: System Current Drain (Continued)

Date: 23 DEC 91

Probe S/N: A-2

6. 10^5 CPM source.

   Current: 10.95 - 11.25 mA

7. 10^5 CPM source, "chirp" on.

   Current: 17 - 27 mA

8. 10^5 CPM source, "alarm" on.

   Current: 16 - 27 mA

9. 10^6 CPM source.

   Current: 11.2 MA

10. 10^6 CPM source, "chirp" on.

   Current: 17 - 28 mA

11. 10^6 CPM source, "alarm" on.

   Current: 16 - 26 mA

12. 10^6 CPM source, light on, "chirp" on.

   Current: 30 - 40 mA

XIV. LOW TEMPERATURE (-32°C) TEST

A. Criteria (-32°C):

The instrument shall be capable of operating with the required accuracy in climatic categories 1 through 6 in AR 70-38.

B. Required Equipment:

1. AN/UDM-6 Radiac Calibrator.
2. AN/PDR-77 Calibration Fixture.
3. Calibrated Environmental Chamber.

C. Test Procedure.

1. Record the date, the serial numbers of the radiacmeter, the alpha probe, the AN/UDM-6 calibrator, the calibrated activity of the 10^4 CPM source from the AN/UDM-6, and the calibrator's calibration date in the indicated spaces on the data sheet. Record the model, serial number, and calibration date of the environmental chamber in the indicated spaces on the data sheet.

2. Place the alpha probe inside the environmental chamber along with the calibration fixture and the 10^4 CPM source from the AN/UDM-6.

3. Connect the probe to the radiacmeter using one of the penetrations through the wall of the chamber. Turn the AN/PDR-77 on, and place it in the count rate mode. Record the count rate at ambient temperature in the indicated space on the data sheet.

4. Set the chamber controls for -32°C and turn the chamber on. Record the time in the indicated space on the data sheet.

5. After at least two hours, record the time, temperature, and count rate in the indicated spaces on the data sheet.

6. At various times for another two hours, record the time, temperature, and count rate in the indicated spaces on the data sheet.

7. If the difference between the first and last count rate readings is greater than ±10%, the probe has failed the test.

DATA SHEET

Type Test: Low Temperature (-32°C). DATE: 16 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984102 Probe S/N: A-2

Chamber Model: TENNEY Jr. Chamber S/N:

Chamber Calibration date:

Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
BP-1482	11799		

Mode: Ratemeter X Scalar___ Preset Time Interval (Min):

Test Data

Time	Count Rate	Temperature (°C)
0950	11.9 K	20°
0955	11.9K	-4
1030	11.9 K	-32
1100	11.9 K	-32
1130	11.9 K	-32
1315	11.9 K	-32
1350	11.9 K	-32
1450	11.8 K	-32

1. Percentage difference between initial and final count rate readings: -.85 %

DATA SHEET

Type Test: Low Temperature (-32°C). DATE: 17 DEC 91

Alpha Calibrator, AN/UDM-6 S/N: A1003

Calibration date: 9 FEB 90

Radiacmeter S/N: SM984103 Probe S/N: A-1

Chamber Model: TENNEY Jr. Chamber S/N:

Chamber Calibration date:

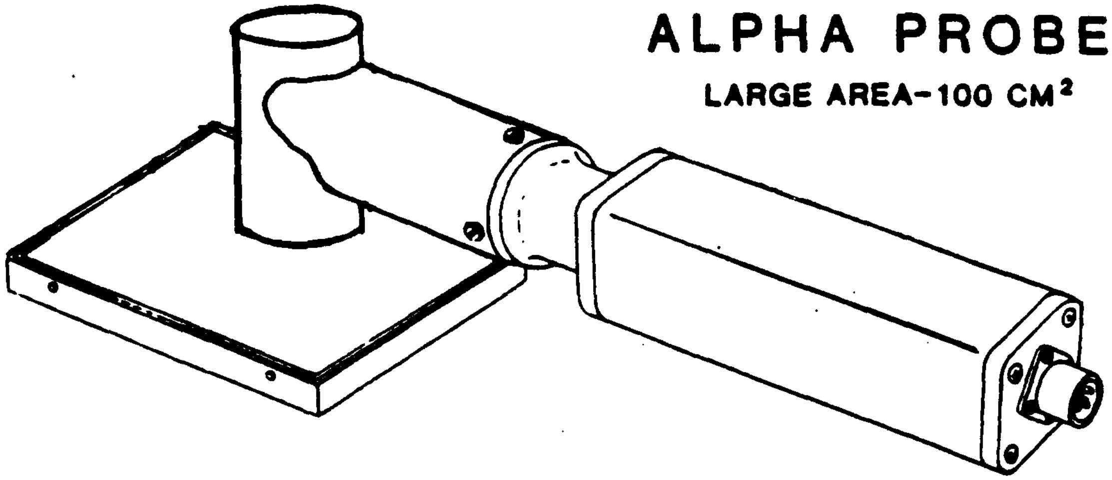
Alpha Source S/N	Calibrated Activity (CPM)	Attenuator Number	Calibrated Attenuated Activity (CPM)
BP-1482	11799		

Mode: Ratemeter X Scalar___ Preset Time Interval (Min):

Test Data

Time	Count Rate	Temperature (°C)
0930	12.6	22°
1020	12.4	-32
1046	12.6	-32
1130	12.6	-32
1325	12.6	-32
1550	12.8	-32

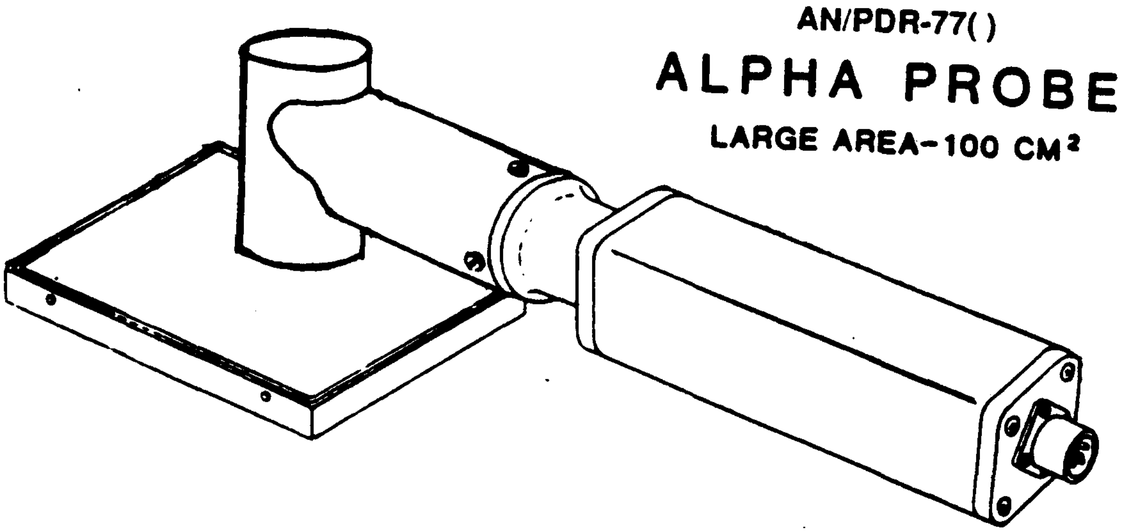
1. Percentage difference between initial and final count rate readings: +1.6 %



Characteristics
Probe SN: AP094001 (A-1)
Active Area: 92 cm^2
Window Thickness (AL): 6000 A°
Count Accuracy (2Pi): +7.6% segment area #2-2.8 cm dia. Pu^{239} source
+6.8% Total Detector Face Area (calculated)
Gamma Response: 0 CPM at 1R/hr (Cs^{137})
Uniformity in Accuracy: Center Area Segment #5 +30%
Corner Area Segments #1,3,7,9 -5%,-4%,+1%,-1%
Scintillator: ZnS (Ag)
Operating Temperature: -25°F to 140°F
Detection Threshold (MeV): 1.8 to 2.4 MeV
Range of CCM for measured accuracy: 26 CPM to 850 KCPM
Average Detector Area Count Accuracy: 106.8%

Figure 14

Prototype Alpha Probe Characteristics (Probe A-1)



Characteristics
Probe SN: AP094003 (A-2)
Active Area: 92 cm^2
Window Thickness (AL): 6000 A°
Count Accuracy (2Pi): -1.7% segment area #2-2.8 cm dia. Pu^{239} source
-16.4% Total Detector Face Area (calculated)
Gamma Response: 0 CPM at 1R/hr (Cs^{137})
Uniformity in Accuracy: Center Area Segment #5 +17%
Corner Area Segments #1,3,7,9 -33%,-30%,-41%,-45%
Scintillator: ZnS (Ag)
Operating Temperature: -25°F to 140°F
Detection Threshold (MeV): 1.8 to 2.4 MeV
Range of CCM for measured accuracy: 21 CPM to 1358 kCPM
Average Detector Area Count Accuracy: 83.6%

Figure 14a

Prototype Alpha Probe Characteristics (Probe A-2)

Appendix A

US Army Alpha Monitoring and Survey Meter Requirements

Revised Abbreviated Performance Characteristics (APC) for an Alpha Monitoring and Survey Meter

1. **General.** These APCs are for a lightweight, portable, battery-operated radiacmeter for the detection of alpha radiations.

2. **Performance Characteristics.**

a. Environmental Considerations.

(1) (Essential) The instrument shall be capable of operating with the required accuracy (see paragraph 2b(2) below) in climatic categories 1 through 6 as defined in AR 70-38. It shall be capable of safe storage and transportation without permanent impairment of its capabilities from the effects of high and low temperature storage and transit conditions as defined in categories 1 through 6 of AR 70-38. (Desirable) The instrument shall be capable of operation with the required accuracy in cold and extreme cold climatic conditions and capable of safe storage without permanent impairment of its capabilities from the effects of extreme low temperature conditions as defined in categories 7 and 8 of AR 70-38.

(2) (Essential) The instrument shall be capable of withstanding, without damage for one year, corrosion caused by exposure to an ocean beach environment.

(3) (Essential). The instrument shall operate satisfactorily after submersion for at least 30 minutes in 3 feet of fresh or salt water. External and internal parts shall not support fungal growth.

b. Operational Characteristics.

(1) (Essential) The instrument shall detect alpha radiations, and shall indicate on a meter the rate in either counts per minute (CPM) or disintegrations per minute per 100 square centimeter (DPM/100cm^2) at which alpha particles are impinging upon the detector. The read-out units should be user-selectable. Desirable meter ranges are: 0-10^6 CPM and 0-10^5 DPM/100cm^2.

(2) (Essential) Response of the equipment shall be linear. Instrument readings at any point within the upper 80 percent of the 0 to 1000 CPM range and the upper 90 percent of all other ranges shall be within 10 percent (plus or minus) of the readings caused by a known concentration of plutonium (PU-239 or PU-238).

(3) (Essential) The alpha energy threshold for detection shall be 3 Mev or less at the surface of the window. The equipment shall be sensitive to alpha particles of all energies above this threshold.

(4) (Essential) The equipment shall not be significantly affected by non-ionizing radiation. Also, the equipment's ability to detect alpha radiation shall not be significantly affected by other forms of ionizing radiation. The gamma response of the instrument shall not exceed 25 counts/minute per millirad/hr of gamma radiation at the location of the instrument for a gamma field of up to 1 rad/hr resulting from fissioned nuclear weapons material (gamma energies approximated by Cesium 137); therefore, in a 1 rad/hr gamma

field the instrument response due to gamma radiation must not exceed 25,000 counts/minute.

(5) (Essential) The equipment shall operate as specified for at least 50 hours per set of batteries, including 4 hours intermittent operation of meter with internally illuminated dial. Changing of the batteries shall not require recalibration of the equipment. It should be possible to easily change batteries using only a screwdriver.

(6) (Essential) The equipment shall be calibrated against plutonium 239 or plutonium 238 (see paragraph 3h). The meter indication shall be proportional to the concentration of active material of the source.

(7) (Essential) The meter shall be direct reading. Calibration curves are unacceptable.

(8) (Essential) The equipment shall be capable of operating with the required accuracy within 2 minutes after being turned on following a period of inactivity of at least 60 minutes.

(9) (Essential) The equipment shall be zero stable, and shall not drift beyond the specified accuracy over the battery operating life (see paragraph 2b(5) above). Replacement of batteries shall restore the reading to within the limits allowed under reproducibility (paragraph 2b(2), above) without recalibration.

(10) (Essential) The equipment shall maintain its required accuracy during normal use for at least 6 months without recalibration.

(11) (Essential) Reliability, Availability and Maintainability (RAM). The RAM requirements are stated in terms of Mean Time Between Operational Mission Failure (MTBOMF), Mean Time to Repair (MTTR), Maintenance Ratio (MR) and Operational Availability (AO).

Operational Requirements at IOC:

I. Nuclear Accident/Incident Control (NAIC) Mission

Case A. Radiacmeter and Alpha Probe

Reliability

MTBOMF	142 hours

Maintainability

MTTR (DS)	1.0 hour
MTTR (GS)	1.0 hour
MR (DS)	0.0025 mmh/op. hr.
MR (GS)	0.006125 mmh/op. hr.

Availability

Ao	0.99

Case B. Radiacmeter and X-ray Probe

Reliability

MTBOMF	480 hours

Maintainability

MTTR (DS)	1.0 hour
MTTR (GS)	1.0 hour
MR (DS)	0.0 mmh/op. hr.
MR (GS)	0.00275 mmh/op. hr.

Availability

Ao	0.99

Case C. Radiacmeter and Beta/gamma Probe

Reliability

MTBOMF	725 hours

Maintainability

MTTR (DS)	1.0 hour
MTTR (GS)	1.0 hour
MR (DS)	0.0 mmh/op. hr.
MR (GS)	0.001831 mmh/op. hr.

Availability

Ao	0.99

II. Nuclear Storage Monitoring Mission

Reliability

MTBOMF	142 hours

Maintainability

MTTR (DS)	1.0 hour
MTTR (GS)	1.0 hour
MR (DS)	0.0025 mmh/op. hr.
MR (GS)	0.006125 mmh/op. hr.

Availability

Ao	0.99

III. M43A1 Monitoring Mission

Reliability

MTBOMF	142 hours

Maintainability

MTTR (DS)	1.0 hour
MTTR (GS)	1.0 hour
MR (DS)	0.0025 mmh/op. hr.
MR (GS)	0.006125 mmh/op. hr.

Availability

Ao	0.99

(12) (Essential) At least 85 percent of the instruments in storage shall function properly after a period of storage of at least 3 years (see paragraph 2a(1) above).

(13) (Essential) A check switch will be provided to insure adequate battery voltage for operation.

(14) (Essential) The proposed device will be compatible with a beta/gamma probe. The radiacmeter portion of the instrument will have the capability to automatically recognize the type of probe to which it is connected, and to adjust the display accordingly, without operator action. The alpha and beta/gamma probes need not be simultaneously operated. Switching between the two probes will not create a need to recalibrate the instrument.

(15) (Essential) The proposed device will be entirely auto-ranging, and its display shall be digital. No manual scale changing or use of analog displays will be allowed. The display shall indicate counts per minutes (cpm) when the alpha probe is in use, and millirads per hour (mR/hr) when the beta/gamma probe is in use.

(16) (Essential) The display shall feature an automatic warning of low battery level, which shall operate entirely without operator action.

(17) (Essential) The instrument will be furnished with a Th-232 check source to allow the operator to verify that the instrument is functioning. The activity level of the check source will be low enough so that it does not require a license.

(18) (Essential) The radiacmeter portion of the instrument will be furnished with Built in Test (BIT) software to monitor all internal functions. A sequence of test functions will be initiated by a single operator action (e.g., pressing a single button) and then proceed automatically. Any malfunctions detected shall be indicated on the display and also by the audio alarm.

(19) (Essential) The instrument will be equipped with a count rate alarm. The operator will be able to change the alarm level, and also to display the current alarm level on the radiacmeter display, without opening the case and without the use of tools.

(20) (Essential) The instrument will have both visual and audio alarms. The radiacmeter will have the capability of silencing the audio alarm without disabling the visual alarm.

(21) (Essential) The instrument will be powered by batteries now in the standard army inventory. It is desirable that these be either BA 3090 (9 volt) or BA 3030 ("D" cells).

(22) (Essential) The instrument will operate without disruption in the presence of electromagnetic radiation produced by standard military equipment commonly operated in the vicinity of alpha monitoring equipment. The instrument will also emit no electromagnetic radiation that will cause disruption to any military equipment commonly operated in the vicinity of alpha monitoring equipment.

3. **Physical Characteristics.**

a. (Essential) The complete equipment shall consist of a radiacmeter, alpha probe, carrying harness, carrying case, radioactive test sample to check all ranges, and headphones. Weights and dimensions for the radiacmeter and probe shall not exceed the following:

	Dimensions (inches)			Weight (pounds)
	Length	Width	Height	
Radiacmeter	9	5	8	8
Alpha Probe (excluding handle)	9	4	4	3

b. (Desirable) The instrument design shall permit the operator to survey smooth surface areas from a standing position.

c. (Essential) The bottom of the probe shall be protected by a grid type plate which will protect the sensitive area of the probe during use.

d. (Essential) The sensitive area is defined as that area of the probe which is sensitive to alpha radiations. The total sensitive area shall be at least 25 cm^2, and not greater than 100 cm^2.

e. (Desirable) The equipment shall have as an accessory probe to detect the presence of plutonium under adverse conditions (e.g., rain, snow, and after firefighting operations). The probe shall not weigh more than 2 pounds and the gamma energy response shall cover the energy range from 10 to 60 Kev.

f. (Essential) Design of the equipment shall be such as to minimize contamination by chemical or biological agents or radioactive materials. Components of the equipment shall be readily capable of decontamination with minimum effect on their proper operation. Nuclear-hardening is not required.

g. (Essential) A self-contained power source for the alphameter and all integral devices shall be provided.

h. (Essential) The instrument shall be capable of being calibrated by standard army calibrators (i.e., AN/UDM-6).

i. (Essential) The equipment shall be constructed to withstand transport in vehicles over rough terrain and in aircraft as prescribed in AR 70-38.

4. **Other Characteristics.**

a. (Essential) Operating personnel shall be adequately protected against high voltages and from any radioactive materials used for a calibration check or for any other purpose.

b. (Essential) The equipment shall be designed to conform with human factor engineering principles, including consideration of ease in handling and carrying and operations in confined spaces.

c. (Essential) The design of the equipment shall permit operation when protective equipment is worn, e.g., protective mask or respirator and heavy gloves.

d. (Essential) The equipment shall be capable of operation by selected military personnel after a minimum period of instruction to include before, during, and after operational checks, use, and maintenance. Instrument design will be such that changing of batteries can be accomplished by personnel wearing protective gear (see paragraph 4c).

5. **Pre-Programmed Product Improvement (P^3I).** (Desired) The instrument will have a Sodium Iodide accessory probe for neutron detection and an external speaker.

Appendix B

Patent Docket: Scintillator Assembly and Assembly of Alpha Particle Detector

ABSTRACT OF THE DISCLOSURE

A scintillator assembly for use in the detection of alpha radiation includes a body of optically-transparent epoxy and an amount of phosphor particles embedded within the body adjacent one surface thereof. When making the body, the phosphor particles are mixed with the epoxy when in an uncured condition and permitted to settle to the bottom surface of a mold within which the epoxy/phosphor mixture is contained. When the mixture subsequently cures to form a hardened body, the one surface of the body which cured against the bottom surface of the mold is coated with a thin layer of opaque material for preventing ambient light from entering the body through the one surface. The layer of opaque material is thereafter coated with a layer of protective material to provide the assembly with a damage-resistant entrance window.

SCINTILLATOR ASSEMBLY FOR ALPHA RADIATION DETECTION AND METHOD OF MAKING THE ASSEMBLY

Background of the Invention

This invention was made with Government support under Contract No. DE-AC05-84OR21400 awarded by the U.S. Department of Energy to Martin Marietta Energy Systems, Inc. and the Government has certain rights in this invention.

This invention relates generally to the detection of alpha radiation and relates, more particularly, to instruments used in the detection of alpha radiation.

Conventional alpha scintillation survey instruments commonly include an optically-transparent light pipe which is optically coupled to the front of a photomultiplier tube. Disposed across the light pipe opposite the photomultiplier tube is a thin layer of phosphor, such as silver-activated zinc sulfide. During use of such an instrument, alpha particles interact with the phosphor layer to create light photons which, in turn, are guided by the light pipe onto the photomultiplier tube. In order to protect the photomultiplier tube from saturation by ambient visible light, the instrument is commonly housed in a metal casing and covered with a thin, opaque radiation entrance window.

The entrance window is relatively thin to permit the passage of alpha particles and to avoid any significant reduction of kinetic energy possessed by the particles as they pass through the window. Entrance windows of conventional alpha scintillation instruments commonly are provided by a layer of aluminized Mylar® possessing a thickness of about 6.35 micrometers (i.e., about 0.25 mil). Mylar material possessing such a thickness is known to provide a satisfactory opaque shield against ambient light and is thin enough for most alpha particles to penetrate. However, such a window is relatively fragile and is easily punctured, torn or scratched. In order to render a conventional survey instrument more durable for use in field environments, the fragile entrance window may be replaced with a meshed Mylar ® window screen or a micromachined silicon wafer may be incorporated within the instrument to obviate the fragile entrance window. However, neither of the instruments which result from the aforementioned use of the meshed window screen or micromachined silicon wafer have been found to be both highly efficient and suitably rugged. It would be desirable to provide an instrument for the detection of alpha radiation which combines both high efficiency and ruggedness.

Accordingly, it is an object of the present invention to provide a new and improved scintillator assembly for use in an alpha radiation detector which promotes high efficiency during operation of the instrument and is sufficiently rugged for use in field environments and a method of making the assembly.

Summary of the Invention

This invention resides in a scintillator assembly for use in the detection of alpha radiation and a method of making the assembly.

The scintillator assembly includes a body having a front surface against which alpha particles desired to be detected impinge and includes an optically-transparent medium and an amount of phosphor embedded within the optically-transparent medium adjacent the front surface of the body. The front surface is coated by a relatively thin layer of opaque material for preventing ambient light from entering the body through the front surface thereof, and the layer of opaque material is coated by a layer of protective material which is transparent to alpha particles moving through the protective material layer to provide the assembly with a damage-resistant entrance window.

The method of making the scintillator includes the steps of providing a mold having an interior having a relatively smooth bottom surface, providing an amount of phosphor in particle form, and providing an amount of optically-transparent medium in an uncured condition wherein the optically-transparent medium has a relatively low viscosity when in its uncured condition and is curable to a hardened condition. The amount of phosphor is mixed with the uncured amount of optically-transparent medium, and the resulting phosphor/medium mixture is placed within the mold. A major portion of the phosphor is then permitted to settle within the optically-transparent medium to the bottom surface of the mold, and the mixture is then permitted to cure to form a hardened body. The hardened body is thereafter removed from the mold and the surface of the body which cured against the bottom surface of the mold (providing the front surface of the body in the scintillator assembly) is coated with a relatively thin layer of opaque material to prevent ambient light from entering the body through the body surface. The layer of opaque material is subsequently coated with a layer of protective material to provide the assembly with a damage-resistant entrance window.

Brief Description of the Drawings

Fig. 1 is a fragmentary transverse cross-sectional view of an embodiment of a scintillator detector assembly in accordance with the present invention.

Fig. 2 is a view of the Fig. 1 assembly similar to that of Fig. 1, shown exploded.

Fig. 3 is an exploded perspective view of a mold used in connection with the making of a component of the Fig. 1 assembly.

Fig. 4 is a cross-sectional view taken along line 4-4 of Fig. 3.

Figs. 5 and 6 are views illustrating various steps involved in making the Fig. 1 assembly.

Detailed Description of an Illustrated Embodiment

With reference to Figs. 1, and 2, there is shown an instrument 18 for use in the detection of alpha radiation and within which an embodiment of a scintillator assembly, indicated

20, is incorporated. In addition to the assembly 20, the instrument 18 includes a photomultiplier tube 22 and an amount of phosphor material, described herein, positioned in front of the tube 22. During operation of the instrument 18, particles of alpha radiation interact with the phosphor material to create photons, and the created photons are guided, or focused, onto the front, indicated 23 in Fig. 2, of the photomultiplier tube 22. The means and methods by which the created photons are sensed with the photomultiplier tube are well known in the art so that a more detailed description of the detection componentry of the instrument 18 is not believed to be necessary.

The scintillator assembly 20 is mounted in the instrument 18 in front of the photomultiplier tube 22 and includes the aforementioned amount of phosphor used in the creation of photons upon interaction with alpha particles. In this connection, the assembly 20 includes a body 24 having a smooth front surface 26 and an opposite back surface 28. A light pipe 25 is attached to the back surface 28 and interposed between the body 24 and the photomultiplier tube 22. The front surface 26 of the body 24 is coated with a layer 30 of opaque material, whose purpose is set forth in greater detail herein, and the opaque material layer 30 is, in turn, coated with a layer 32 of protective material.

The body 24 of the assembly 20 includes an optically-transparent medium 36, such as an optically-transparent epoxy within which an amount of phosphor 38 is embedded. More specifically, the phosphor 38 is embedded within the body 24 so that a major portion of the phosphor amount is positioned adjacent the front surface 26. The epoxy 36 is comprised of a resin and a hardener which when mixed and in an uncured condition, possesses a relatively low viscosity. The amount of phosphor 38 is added to and mixed with the low-viscosity epoxy in a powdered form and permitted to gravitationally settle within the mixture before the epoxy cures to a hardened condition. When, therefore, the epoxy 36 subsequently cures to a hardened condition to form the body 24, the major portion of phosphor 38 is collected in a layer adjacent the lowermost surface of the hardened mixture. In order, therefore, that the phosphor 38 is gravitationally collected adjacent the front surface 26 of the body 24 during the formation of the body 24, the body 24 is molded with its front surface 26 facing downwardly.

An example of an epoxy suitable for use as the optically-transparent medium of the body 24 is available under the trade designation Eccobond 27 from Emerson & Cummings, Inc. of Canton, Massachusetts. Preferably, the phosphor 38 of the body 24 is silver-activated zinc sulfide [ZnS(Ag)] having a particle size of about twelve micrometers. Silver-activated zinc sulfide possesses desirable qualities as an alpha-sensitive medium and when utilized in the body 24, enhances the collection efficiency of the photomultiplier tube 22. During formation of a body 24 (described in greater detail herein) wherein a phosphor layer possessing a thickness of about 0.13 cm(0.05 inches) is desired, an amount of phosphor powder is mixed with the epoxy so that upon settling within the mixture, about 7.0 milligrams per square centimeter of phosphor powder is deposited along the lower surface of the mixture.

To form the body 24 and with reference to Fig. 3, a mold 40 is prepared for holding a mixture of uncured epoxy and phosphor. Such a mold 40 may be prepared by machining a substantially square opening 42 in a block of polyethylene or tetrafluoroethylene, such as is available under the trade designation Teflon from E.I. du Pont de Nemours & Company, Inc., of Wilmington, Delaware to form a frame 44 for the mold 40. For present purposes, the opening 42 in the illustrated frame 44 as measured across its upper surface is about 4.219 inches by 4.219 inches (i.e., 100 square centimeters), and the inside surfaces of the frame 44 are milled at about a forty-five degree angle between the top and bottom surfaces as best shown in Fig. 4.

To form a bottom for the mold 40, a suitably-sized piece 46 is cut from a sheet of polyester film, preferably of a type which is available under the trade designation Mylar from E. I. du Pont, de Nemours & Co., Inc. One side, indicated 48 in Fig. 3, of the Mylar piece 46 is then coated with a thin layer of a mold release agent, such as that which is available under the trade designation Ram Mold Release 225 from Ram Chemicals of Garcena, California. During a coating operation, the Mylar piece 46 is preferably attached to a spinner (not shown) and rotated so that the one side 48 of the Mylar piece 46 to which the mold release agent is to be applied is spun about its center at about 3,000 revolutions per minute. The mold release agent (in a liquid form) is then applied to the center of the side 48 of the spinning piece 46 so that the spinning action of the piece 46 coats the side 48 with the release agent and slings excess release agent from the side 48.

The one side 48 of the Mylar piece 46 is then coated with an opaque material of the type desired to provide the layer 30 for the body 24. In the depicted embodiment, the opaque material used for coating the piece side 48 is aluminum and is applied to the piece side 48 by an evaporation process so that the thickness of the aluminum coating upon the piece side 48 is about 2000 angstroms. The aluminum-coated Mylar piece 46 is then tightly stretched across a glass plate 50 (measuring 6.0 inches across its face) so that the aluminum-coated side 48 of the Mylar piece 46 faces away from the plate 50. When stretching the Mylar piece 46 onto the plate 50, care should be is taken to ensure that no dust particles are trapped between the piece 46 and the plate 50.

The mold frame 44 is then placed upon and attached to the aluminum-coated Mylar piece 46 to form the assembled mold 40, best shown in Fig. 5. Attachment of the mold frame 44 to the aluminum-coated Mylar piece 46 is effected with a double-sided tape or some other adhesive positioned between the periphery of the piece 46 and the lower side of the frame 44. Preferably, the attachment of the frame 44 to the Mylar piece 46 forms a sealed bond therebetween to prevent leakage from the interior of the mold when the mold 40 is used. It follows that the sidewalls of the interior of the assembled mold 40 is provided by the inside surfaces of the frame 44 and the bottom of the mold interior is provided by the aluminum coating of the Mylar piece 46.

As mentioned earlier, the medium 36 with which the body 24 is formed is optically-transparent in its hardened, or cured, state and in the depicted embodiment is comprised of the aforementioned Eccobond 27 epoxy from Emerson & Cummings, Inc. The phosphor used in the formation of the body 24 is ZnS(Ag) having a particle size of about 12 micrometers is well-suited for use in the body 24.

With reference to Fig. 5, an amount of uncured epoxy is mixed with a smaller amount of phosphor in a separate container 54 before the epoxy/phosphor mixture 56 is poured into the mold 40. At the outset of such a mixing operation, the aforementioned Eccobond 27 (comprised of a resin and a hardener), 18.5 grams of resin is mixed with [illegible] grams of hardener in the container 54, and then about 800 milligrams of the ZnS(Ag) (12 micrometer particle size) are added to the epoxy mixture. The three parts are then gently mixed together while care is taken to minimize the formation of air bubbles within the mixture. Preferably, the epoxy should be thoroughly mixed and the phosphor uniformly distributed throughout the epoxy mixture.

The epoxy/phosphor mixture 56 is then poured into the mold 40 as shown in Fig. 5. With the aforementioned amounts of resin, hardener and phosphor, the mixture 56 forms a relatively thin layer within the mold 40 having a thickness of about 0.13 cm (0.05 inches). The mold 40, with the mixture 56, is then placed within an oven set at 60 degrees Centigrade and permitted to heat for about thirty minutes. Positioned within the oven for only about thirty minutes, the epoxy does not cure and its viscosity remains low enough that the phosphor particles satisfactorily settle to the bottom of the epoxy/phosphor mixture 56. At the end of the thirty minutes, the mold 40 is removed from the oven.

The light-pipe 25 illustrated in Fig. 6 is constructed of methyl methacrylate and in the depicted embodiment, is in the form of a solid block measuring about 4.219 inches by about 4.219 inches by about 0.4375 inches. With the mixture 56 in at least a partially cured condition within the mold 40, the light-pipe 25 is attached to the upper surface of the body with a suitable epoxy, such as the aforementioned Eccobond 27. In the illustrated embodiment, 10.3 grams of resin and 3.1 grams hardener of Eccobond 27 are mixed together in a suitable container and subsequently applied as a mixture 58 to the center of one side of the light-pipe 25 as shown in Fig. 7. The light-pipe 25 is then placed epoxy-side down into the mold 40 containing the partially-cured epoxy/phosphor mixture 56 so that the epoxy mixture applied to the light-pipe 25 spreads across the upper surface of the mixture 56. With the epoxy mixture 58 sandwiched between the mixture 56 and light-pipe 25, the mixture 58 forms a bonding layer which is substantially free of air pockets.

The mold contents are then permitted to cure to a hardened condition. although the contents of the mold 40 will cure satisfactorily if left undisturbed overnight, the mold 40 may be placed in an oven to reduce the time normally necessary for curing.

Upon curing of the mold contents to a hardened condition, the Mylar piece 46 is gently peeled from the hardened mixture 56, or more specifically, from the front surface 26 of the hardened body 24 so that the aluminum with which the piece side 48 was coated remains attached to the front surface 26. The body 24 is then removed from the mold frame 44 and prepared for the application of additional aluminum on the front surface 26. To this end, a thin layer of mold release agent is applied to the front surface in a spin-coating process. In particular, the body 24 is attached to a spinner (not shown), and its front surface 26 is spun about its center at about 3000 revolutions per minute. The mold release agent is then deposited upon the center of the spinning surface 26 so that the spinning action of the body 24 slings the mold release agent across the front surface 26.

With a thin layer of mold release agent applied to the aluminized front surface 26, an additional layer of aluminum is applied to the front surface 26 by an evaporation process (i.e., e-beam evaporation) so that the additional layer of aluminum has a thickness of about 2000 angstroms. The steps of spin-coating a thin layer of mold release agent onto the front surface 26 and applying an additional layer (about 2000 angstroms in thickness) of aluminum to the front surface 26 are thereafter repeated until the total thickness of the aluminum applied to the front surface 26 is completely light-tight. It has been found that an aluminum coating possessing a thickness of about 8000 angstroms provides the front surface 26 with satisfactory light-tight characteristics.

The aluminum coating (indicated 30 in Figs. 1 and 2) applied to the front surface 26 of the body 24 is thereafter coated with a layer 32 of hardcoat material in a spin-coating process. In this connection, the body 24 is attached to a spinner (not shown) and rotated so that the aluminum-coated front surface 26 rotates about its center at about 3000 rpms. An uncured amount of hardcoat material such as cyanoacrylate available under the designation Zip Grip 4404 from Devcon Corporation is then deposited upon the center of the front surface 26 so that the spinning action of the body 24 coats the aluminum layer 30 with the hardcoat material and slings off of the body 24 any excess hardcoat material. The layer 32 of hardcoat is thereafter permitted to cure to complete the assembly 20, and the assembly 20 is optically-attached to the photomultiplier tube 22 in a manner well-known in the art.

The resulting scintillator assembly 20 is advantageous in that its entrance window, provided by the hardcoat layer 32, is resistant to scratches, tears, punctures and other forms of physical damage and is resistant to many types of chemicals which may damage conventional scintillator assemblies. Hence, the assembly 20 is well-suited for use in field environments. Moreover, the assembly 20 is watertight and suitable for use in high humidity areas and liquid or wastewater streams. In addition, the components of the assembly 20 are commercially available at relatively low costs thus rendering the material cost of the assembly 20 relatively low. Furthermore, the assembly 20 may be manufactured in the size, shape or form required by the application or to retrofit existing alpha scintillator detector units. Still further, the overall efficiency of the assembly 20 has been found to be greater than conventional scintillator assemblies and is advantageous in this respect.

It will be understood that numerous modifications and substitutions can be had to the aforementioned embodiments without departing from the spirit of the invention. For example, although the application of opaque material, e.g. aluminum, to the front surface 26 of the assembly body 24 has been shown and described as effected by e-beam evaporation, the opaque material may be effected by sputtering, anodization, diffusion or chemical reaction in accordance with the broader aspects of the invention. Accordingly, the aforementioned embodiments are intended for the purpose of illustration and not as limitation.

Attorney Docket No.: 514-X
Inventors: Stephanie Anne McElhaney,
Martin Linwood Bauer and Marion McKinley Chiles
Title: Scintillator Assembly for Alpha Radition
Detection and Method of Making the Assembly

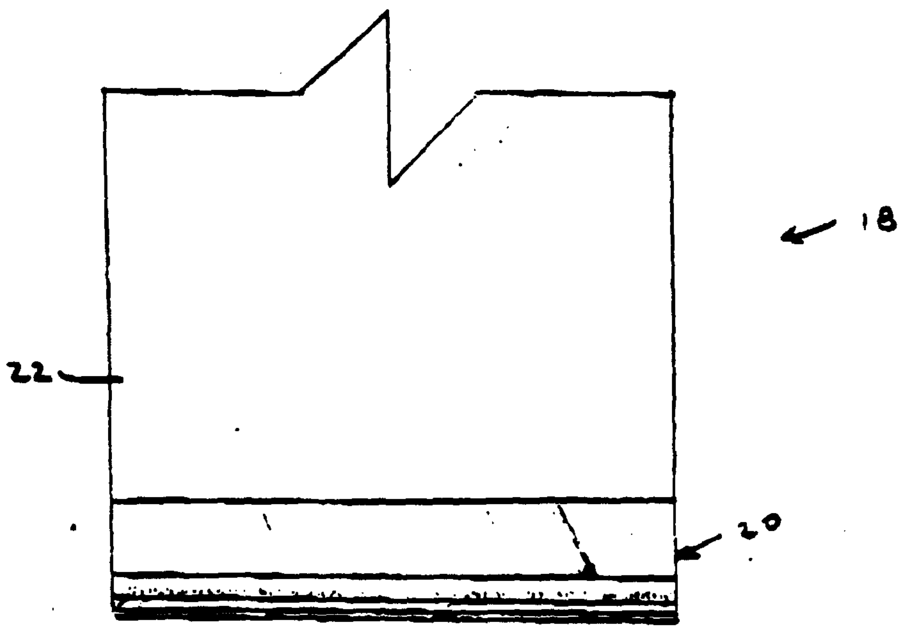
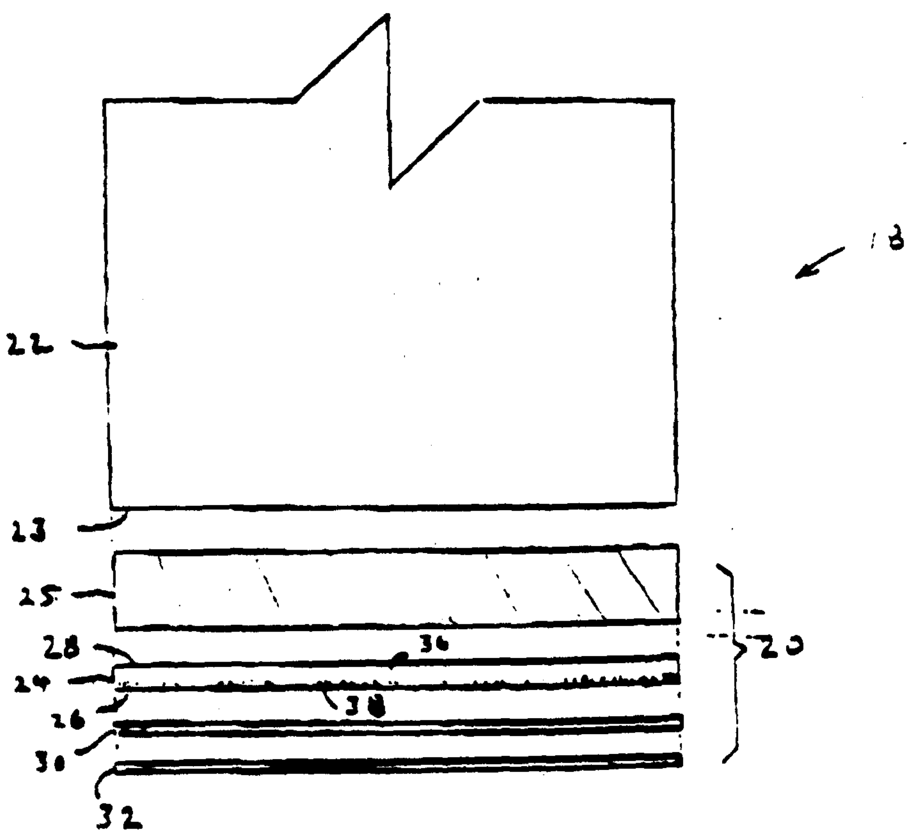


FIG. 1



Attorney Docket No.: 514-X
Inventors: Stephanie Anne McElhaney,
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Title: Scintillator Assembly for Alpha Radiation
Detection and Method of Making the Assembly

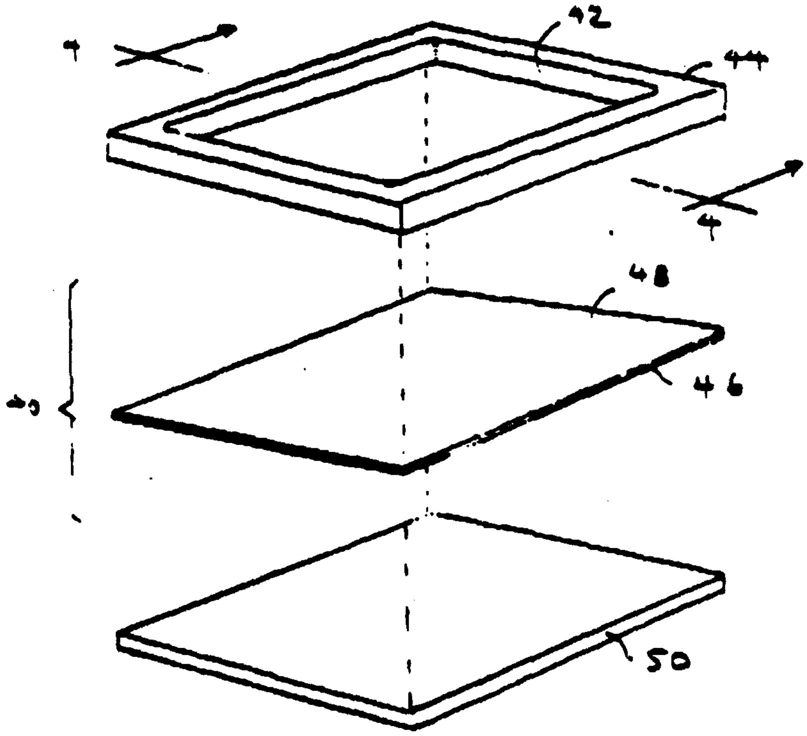
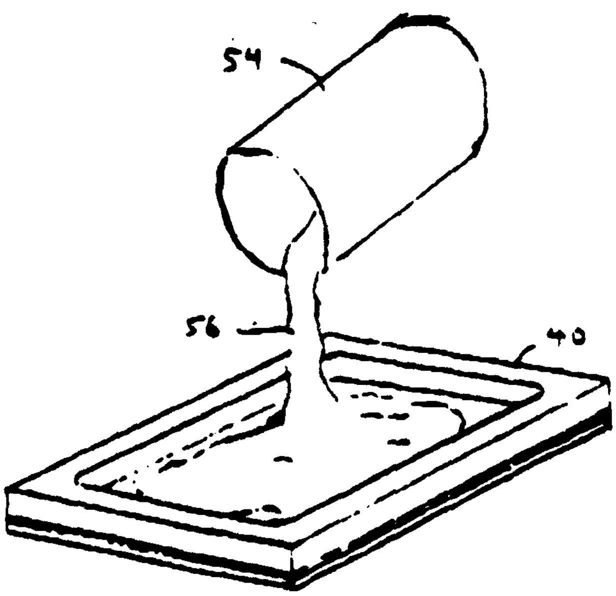
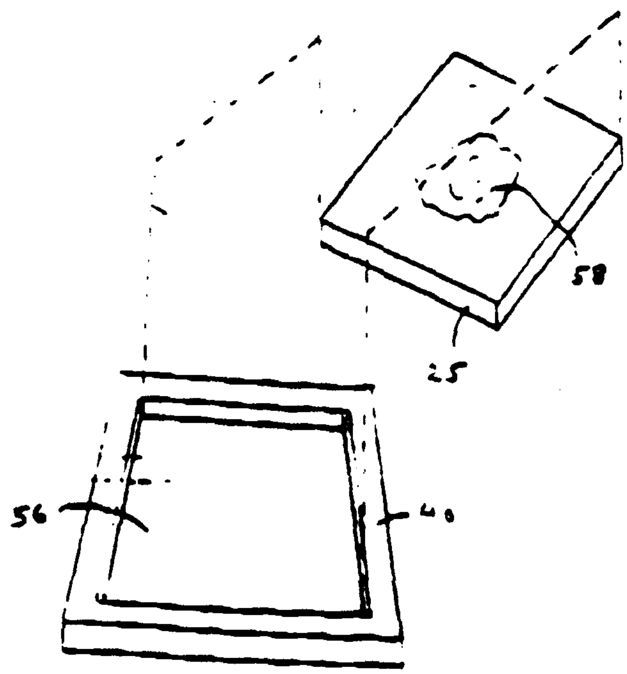


FIG. 3

FIG. 4





Appendix C

Certificate of Calibration, AN/UDM-6

US ARMY AREA TMDE SUPPORT CENTER-SACRAMENTO
SACRAMENTO ARMY DEPOT
SACRAMENTO, CALIFORNIA 95813-5035

U.S.ARMY PRIMARY NUCLEONICS LABORATORY

REPORT OF CALIBRATION

OF

RADIAC CALIBRATOR, AN/UDM-6
S.N. A-1003

FOR

CECOM SAFETY OFFICE
AMSEL-SF-RER
FORT MONMOUTH, NJ 07703-5000

The alpha particle emission rate from the active surfaces of the sources are:

Serial Number	Counts/Minutes	Uncertainty
P-1559	1,376	+/- 2.8%
P-1482	11,799	+/- 2.4%
P-1907	121,560	+/- 2.3%
P-2372	1,113,522	+/- 2.2%

The counting was performed using a 2 Pi NMC PC-4 gas flow immersion counting chamber. This calibration is traceable to National Institute of Standards and Technology. The uncertainties represent the sums of the limits of the random errors at the 99 percent confidence level and the maximum systematic errors in the measurement.

Charles R. Wallace
CHARLES R. WALLACE
CHIEF, APNL
USACRC-Sacramento

DATE: FEBRUARY 9, 1990
Report No. W4GV39227N

This certification is valid for 720 days from the above date. Recertificatio is advised after 720 days.

DEPARTMENT OF THE ARMY
DISTRICT TMDE SUPPORT CENTER SACRAMENTO
SACRAMENTO ARMY DEPOT

SACRAMENTO, CA 95813-5035

AMXTM-GC-S

24 JAN 92

NUCLEONICS LABRATORY BRANCH

REPORT OF CALIBRATION

For
RADIAC CALIBRATOR, AN/UDM-6
Serial No. A1160
Report No. W4GV39 226N

CALIBRATED FOR: W4GV39

SAFETY OFFICE
ATTN: AMSEL-SF-RER
FORT MONMOUTH
FORT MONMOUTH, NJ 07703

Alpha particle emission rate from the active surfaces of the sources are:

Serial Number	Counts/Minutes	Uncertainty
P3150	1,106	+/ 3.66 %
P2724	13,126	+/ 2.95 %
P2608	144,320	+/ 2.29 %
P3159	1,456,589	+/ 2.14 %

The Counting was performed using a 2 pi NMC PC-4 gas flow immersion proportional count chamber. Uncertainties represent the sums of the limits of random errors at the 99 percent confidence level and the maximum estimated systematic errors in the measurements.

Calibration traceable to National Institute of Standards and Technology. This certification is valid for 720 days from the above date

Charles E. Walton
FOR EDWARD R. ENZ
CHIEF, NUCLEONICS LABRATORY BRANCH

CHARLES E WALTON
TECHNICIAN IN CHARGE OF TEST